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Mr. Arthur H. Jameson, of the Malleable Fittings Company, Branford, Conn., gives the following pedigree of the Steel Dog serving as the frontispiece of this volume:—

The mold was made by Mr. James Gell, the foreman core-maker of our steel department. He used for a pattern a little lead dog given one of his children as a toy. This had evidently been made in a metal mold, and one or two of the seeming imperfections in the steel casting have been exact reproductions of the spots which were found in the original pattern.

The molding was done just as statuary is made. The dog was laid on its side and gated at the joint, the gate being attached to the middle of the back, and the mold being made in two parts only. There were nine drawbacks in all, and the mold which was, of course, of dry sand, was baked in the core oven, and was poured from an ordinary heat of steel, Mr. Gell simply knowing when small castings were poured with bull ladles, and getting his molds poured at the same time without seeking particularly to select extremely hot blows.

The sand used was our ordinary steel foundry sand, but riddled very carefully through rather a finer mesh sieve than we ordinarily use.

Life Size Reproduction of a Steel Dog.

Born in the Stoughton Converter, July 7, 1913.

FOUNDRY-CUPOLA GASES AND TEMPERATURES.

By A. W. Belden,
U. S. Bureau of Mines, Pittsburgh, Pa.

Note by the Secretary.—The monograph printed below forms Bulletin No. 54 of the Bureau of Mines, Department of the Interior. Through the courtesy of the Director of the Bureau, Dr. Jos. A. Holmes, Mr. Belden, the author, was enabled to present the subject matter before the Buffalo Convention of our Association last year. Dr. Holmes has further generously granted us permission to reprint the bulletin in full, for the information of our membership.

Introduction.

Among the investigations that the Bureau of Mines is conducting with a view to increasing efficiency in the utilization of fuels belonging to or for the use of the Government is an investigation of the processes that take place in a foundry cupola during a melt.

Some observations on the results of cupola tests of cokes at the Government fuel-testing plant in St. Louis, Mo., the coke being from coal from many coal fields of the United States, have been stated in a previous bulletin.[1] Especial attention was given to the melting losses that resulted from the use of different grades of coke, light and porous or heavy and dense. These losses amounted in one instance to 52.5 per cent of the iron charged and showed, in convincing manner, the need of exact information in regard to conditions in the fuel bed of the cupola.[2]

Melting losses of iron have been fully appreciated but little understood. The fact that these losses were possible with either light or heavy coke led to the belief that by using small charges

[1] Moldenke, Richard, "The Coke Industry of the United States as Related to the Foundry." Bull. 3, Bureau of Mines, 1910, 34 pp.

[2] For description of the tests at St. Louis, see U. S. Geol. Survey Bull. 336.

so placed that melting would take place in that zone of the cupola where the highest heat and the smallest percentage of oxygen prevailed and by confining all melting to this zone these losses would be eliminated and the economical use of practically any coke produced for metallurgical purposes would become possible. This widening of the field from which coke might be drawn for foundry purposes would serve to place the foundryman in an independent position as regards his source of supply, and would tend to conserve the better grades of coking coals, which are being rapidly exhausted, by making the poorer grades available for mixing with them.

In order to investigate conditions within a cupola, the Bureau of Mines as a first step decided to install a commercial cupola, to sample the gases during their travel from the tuyeres upward, and to determine the temperature of the fuel bed.

Acknowledgments.

Acknowledgment is made of the many courtesies and assistance extended by foundrymen generally, expecially by Maj. J. S. Seaman and the Jamison Coal and Coke Co., of Pittsburgh, Pa., and Dr. Richard Moldenke, of Watchung, N. J., secretary of the American Foundrymen's Association. The author is greatly indebted to the personal assistance of his colaborers in the bureau, both chemists and engineers, who, since the beginning of the investigation in 1911, have made many valuable suggestions.

Equipment.

CONSTRUCTION OF CUPOLA.

A 36-inch standard Whiting cupola was installed. A No. 6 Sturtevant fan was connected to it by a 10-inch pipe 15 feet long. (See Pl. I, A.) The cupola is shown in section in Fig. 1, which gives the several dimensions. Attention is called to a few special features, as follows: Upper and lower tuyeres were provided, but the upper ones were not used in any of the tests. The four lower horizontal tuyeres measured 4 by 6 inches on the outside and 3 by 13 inches on the inside of the cupola and were 14 inches above the bottom. During tests the sand bottom was brought up to within 3 inches of the bottom of the tuyeres in order to save

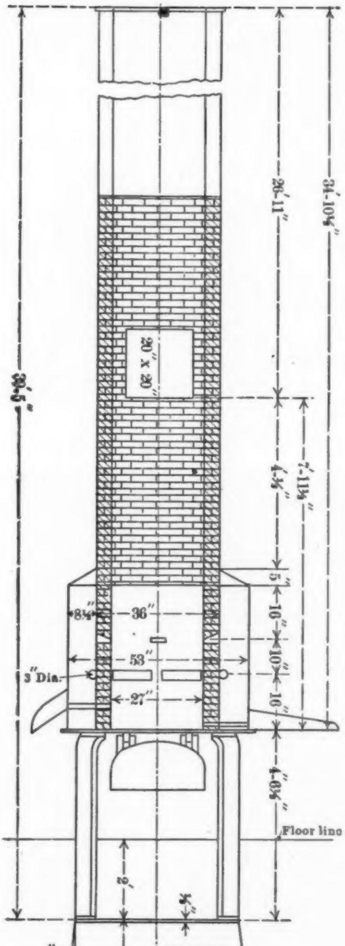


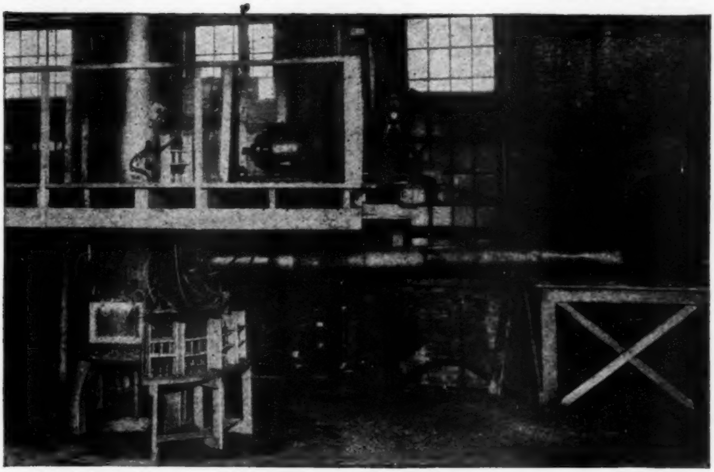
FIG. 1.—SECTION OF 36-INCH FOUNDRY CUPOLA.

as much coke as possible. The tuyere area was 96 square inches, and the area of the cupola, lined to 27 inches internal diameter, was 573 square inches, a ratio of 1 to 5.96.

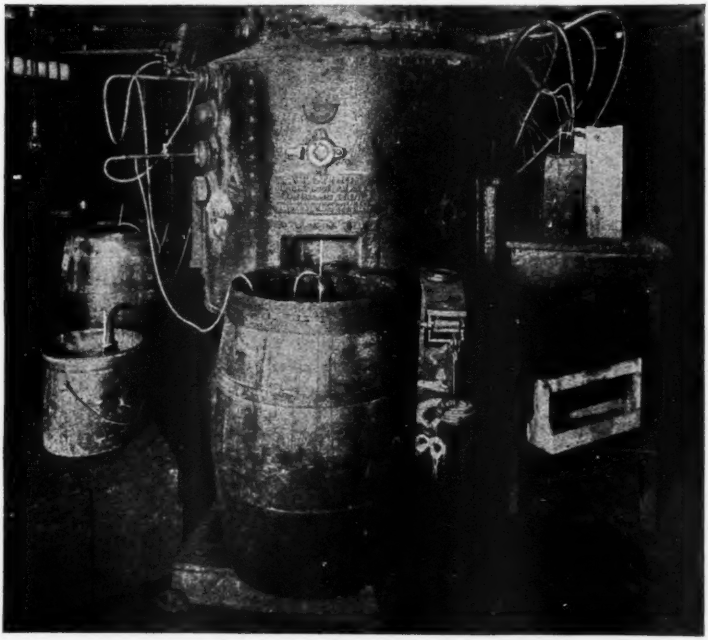
THEORETICAL SECTIONS AND PLANES.

For the purpose of the investigation the cupola was considered as divided into sections by four imaginary horizontal planes, situated as follows: One inch above the top of the inner opening of the tuyeres, and 7, 13, and 19 inches above the top level of the tuyeres. These imaginary planes, beginning at the bottom, are designated in this bulletin as *A*, *B*, *C*, and *D*.

Two-inch holes, as shown at *a*, *b*, *c*, and *d*, of Plate II, *A*, were cut through the wind box and inner shell along the lines at which the planes intersected the wall. Through each hole a 1½-inch pipe 10 inches long was passed, the inner end extending 1 inch past the inner shell into the brick lining, the outer end, extending 1 inch outside the wind box, being threaded to take a cap adapted to fit tightly the sample tube when inserted. The 1½ inch pipe was held in place and leakage of air from the wind box prevented by lock nuts inside and outside. The lock nuts were drawn up after proper packing was inserted between the nut and the inner wall of the wind box, thus making an air-tight joint. Around the pipe at the entrance of the inner wall no packing was used, as the brick lining was cut to make a tight fit, and the sample tubes after insertion were well plastered with fire clay at the point where they passed through the brick. The pressure was not sufficient to cause leakage through to the fuel bed, and all air admitted to the cupola passed through the tuyeres. On the opposite side of the cupola at points designated as *a′*, *b′*, *c′*, and *d′* in Plate II, *A*, holes were cut at levels corresponding to those represented at *a*, *b*, *c*, and *d*, and were fitted with 3-inch pipes similarly to those just described. The exact location of the holes, considered with reference to the inside of the cupola, was as follows: *a* and *a′*, 1 inch above the top of the inner opening of the tuyeres; *b* and *b′*, 6 inches above *a* and *a′*; *c* and *c′*, 6 inches above *b* and *b′*; and *d* and *d′*, 6 inches above *c* and *c′*. Later tests made necessary the insertion of a fifth tube at *e* and *e′*, 7½ inches above *d* and *d′*. All of these tubes except tubes *e* and *e′* passed



A.—CUPOLA WITH FAN AND CONNECTIONS.



B.—APPARATUS FOR DETERMINING TEMPERATURES.

through the wind box. The distance of 7½ inches instead of 6 inches between *d* and *e* was necessary in order to clear the wind box and avoid the difficulty of making the joint air tight. Subsequent tests showed that this placing of the tube had no material effect on the results.

Fan Blower Unsatisfactory.

It was decided to use a fan because a fan had been used in former tests, and because a blower causes pulsations in the blast. The fan was driven by two belts from a counter shaft (Plate I, *A*) connected by a single belt to a line shaft overhead. The fan was connected to the cupola by a 10-inch pipe 15 feet long. This pipe was not straight but had two bends of large radius to insure as little resistance as possible to the flow of air. In the preliminary tests a No. 6 Sturtevant fan blower was used and the pressure determined by means of a blast pressure gauge, graduated in ounces and using water as the registering fluid. This gauge was connected to the wind box, near the top, by means of a rubber tube, as shown in Plate II, *A*. Later, in order to get more delicate readings of pressure, a Pitot tube was installed in the straight part of the pipe, beyond the second bend near the cupola and connected with the gauge. One of the main requirements of the investigation was to determine the quantity of air necessary and to insure the delivery of this quantity during each test.

After many attempts to regulate and control the air, the task was found impossible and a No. 2 10-inch by 35-inch horizontal Roots blower was installed.

Blower Details.

The blower and connections are shown in Plate III. A blower delivers a definite volume of air per revolution when running free, and the loss due to slippage is a definite and uniform quantity under any particular pressure. A reciprocating counter attached to the main shaft of the blower gave an accurate means of determining the revolutions, a Pitot tube connected to a recording pressure gauge indicated the pressure at any time or the average over any period of time, and calculation gave the total volume of

air delivered. In order to make the tests independent of possible delay and of overload difficulties, use of the line shaft was discontinued and a 10-horsepower motor was installed for operating the blower.

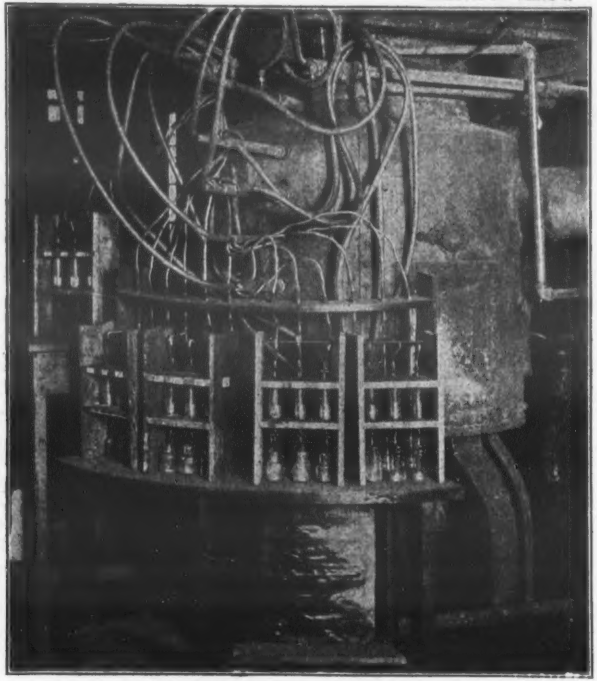
VOLUME OF AIR DELIVERED AND SLIPPAGE.

The blower was tested by the manufacturers at 2, 4, 6, 7, 8, and 16 ounces, and was recalibrated after installation. The curve shown in Fig. 2 was constructed to show the slippage in revolutions per minute at various pressures from 0 to 16 ounces. The amount of air delivered per revolution when running free was 4.8 cubic feet. The following example shows the method of arriving at the total volume of air delivered. During a 15-minute test the blower made 3,497 revolutions and each revolution delivered 4.8 cubic feet of air, so that the total number of cubic feet delivered was 3,497 times 4.8, or 16,785.6 cubic feet. The average pressure, as shown by a pressure gauge connected with a Pitot tube inserted in the air pipe, was 5.3 ounces. The slippage of the blower at this pressure was 22 revolutions per minute. As each slippage revolution represented 4.8 cubic feet loss, the total loss during the test was 1,584 cubic feet ($22 \times 15 \times 4.8$). Deducting this loss of 1,584 cubic feet from the total air delivered with the blower running free ($16,785 - 1,584$) gives 15,201 cubic feet of air actually delivered in 15 minutes, or 1,013 cubic feet per minute.

MEASUREMENT OF PRESSURE.

The simple water manometer, used with the Pitot tube, required the undivided attention of an assistant, who made frequent readings over the whole period of the test in order that the average pressure might be determined. After the method of testing had been decided, a Bristol recording gauge, making a complete revolution in one hour, was connected with the Pitot tube. (See Pl. III.) A record was thus obtained which was continuous over the whole period of the test and facilitated the determination of a true average.

A.—VIEW OF CUPOLA SHOWING LOCATION OF TUBES.



B.—APPARATUS FOR SAMPLING GASES.

Procedure in Tests.

CHARGING OF CUPOLA.

In all tests, whether relating to the character of the gases or to the temperatures, the cupola was lined to 27 inches internal diameter. Coke alone, without iron or flux, was used. The investigation being designed to furnish data as to the action of the fuel, it was necessary to consider only that part of the cupola below and including the melting zone. Complications from the

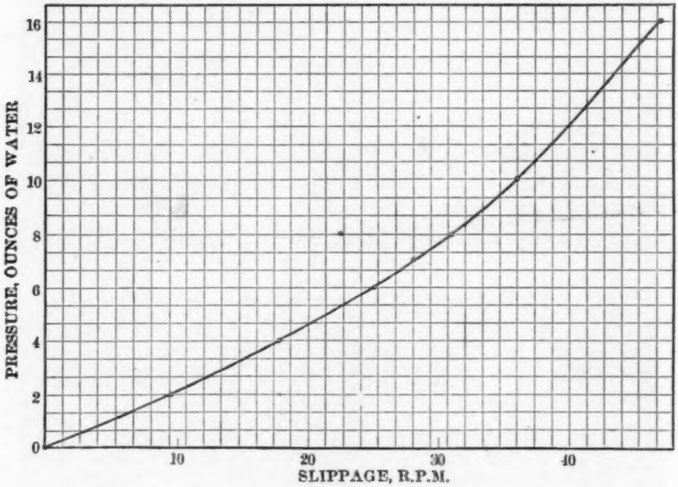


FIG. 2.—SLIPPAGE OF BLOWER UNDER VARIOUS PRESSURES.

use of iron were thus avoided, and the experience of ordinary commercial practice does not indicate that the addition of this material would seriously affect the results obtained from coke alone. The sand bottom was brought up to within 3 inches of the bottom level of the tuyeres. The tubes for collecting gas or measuring temperature were put in position. About 24 inches of coke was placed upon sufficient wood to insure proper kindling. The fire was lighted and the coke allowed to ignite and burn until the top showed bright. Coke in small quantities was added from time to time until well above the top tube, each

CUPOLA WITH BLOWER AND CONNECTIONS.

succeeding charge being held until the preceding charge had burned through. After the last small charge had been added, sufficient time was given to insure its burning evenly over the whole surface of the bed, thus indicating that the burning was over and through the whole bed of coke and was not localized as sometimes happens when proper precautions are not taken. The kindling wood was always completely burned before the last coke was added. This last addition of coke brought the top of the charge to within 6 inches of the charging door. The total weight of coke charged was approximately 750 pounds for each test. Ten minutes after the last coke had been added the blast was turned on and was continued for 15 minutes before the test began. The reason for allowing this length of time was to insure uniform conditions over the whole fuel bed, and was more than that necessary in regular commercial practice to cause the appearance of iron at the cupola spout, an indication that melting has begun.

AIR SUPPLY.

Preliminary tests were made with varying volumes of air per minute, the results suggesting the use of 1,000 cubic feet per minute as a normal condition. As the 36-inch cupola, lined to 27 inches, can melt about 2 tons of iron per hour, 1,000 cubic feet of air per minute checks well with the usual assumption that 30,000 cubic feet of air is required to melt a ton of iron. The varying pressures due to different sizes of coke, the position of pieces of coke with reference to other pieces and the side walls, the effect of slagging and hanging and of other conditions, made impossible the exact regulation of the air supply, but the average of all tests approximated 1,000 cubic feet per minute.

GAS SAMPLING.

In investigating the cupola gases it was necessary to decide on the best method of obtaining samples that would represent the gases in the different cross sections of the fuel bed, and the number of such samples necessary at each cross section, as well as the number of sections.

POINTS OF SAMPLING.

It was decided to consider the fuel bed as being divided by four imaginary planes, located as follows: 1 inch above the top of the inner opening of the tuyeres, and 7, 13, and 19 inches above. In subsequent discussion these planes are designated, starting with that 1 inch above the top level of the tuyeres, as *A*, *B*, *C*, and *D*, and the points from which samples were taken, beginning with the center, as 1, 2, and 3, 2 being 4½ inches from

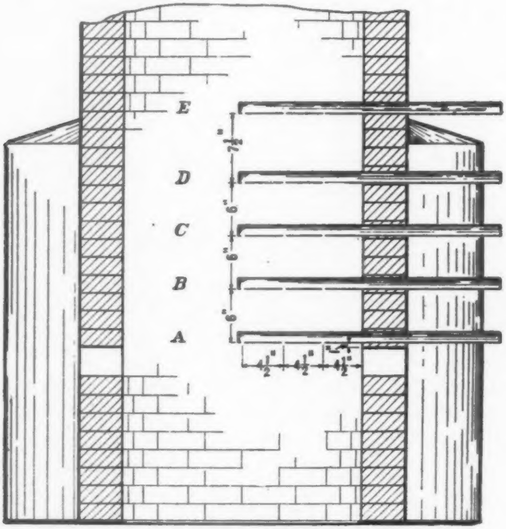


FIG. 3.—POSITION OF PLANES AND GAS-SAMPLING TUBES.

the center, and 3 being 9 inches from the center and 4½ inches from the lining. Fig. 3 shows a vertical section of the cupola and the positions of the imaginary planes and of the sample tubes in place. As Fig. 3 shows, all samples were taken from vertical radial planes that intersected the tuyeres, it being assumed that the gases were the same over any other similar area in the cupola because the entrance of the blast was through tuyeres, the inner openings of which extended practically the whole way around the interior circumference of the lining. Simultaneous samples

taken at other points showed reasonable although not exact agreement.

The preliminary work showed the necessity of examining the bed above plane *D* (Fig. 3), so that examination was made of the gases in a fifth imaginary plane designated as plane *E*. This plane was 7½ inches above plane *D* and 26½ inches above the top level of the tuyeres.

GAS-SAMPLING APPARATUS.

The type of gas-sampling tube used in this work is shown in cross section in Fig. 4. *A* in the figure represents a 1¼-inch iron pipe 48 inches long, one end closed by a circular piece of steel welded in. Three ¼-inch, $\frac{3}{16}$-inch internal diameter, copper tubes, for the collection of the gas samples (represented by *a*, *b*, and *c*, Fig. 4) were brazed into small holes cut through the wall of the pipe and made flush with the outside. These gas-collecting tubes, as well as the enclosing pipe, were kept cool by cold water which entered the outer end through a ½-inch copper tube (*d*, Fig. 4) and passed out through a ¼-inch iron pipe (*e*, Fig. 4). The exit ends of the small tubes, as well as the ½-inch inlet, were held in place and the whole made water tight by brazing. The gas-collecting tubes were connected by ¼-inch lead tubes to ¼-inch copper tubes leading into the wash bottles. The copper tubes were provided with a T at a point convenient for attachment to the mercury-filled sample receivers. The connection was made by means of a 1-mm. internal diameter glass tube, through which a portion of the gas was drawn off continuously from the larger stream. The wash bottle was introduced beyond the point where the gas sample was taken and served to indicate whether the gas was flowing properly through the tubes. No aspiration was necessary, as the sampling tubes extended into the fuel bed and the positive pressure of the blast forced the gases through the tubes. The portion taken for a sample was drawn from the main flow by the flow of the mercury out of the gas receivers. Details of the apparatus are shown in Plate II, *B*. More complete discussion of the method of sampling and analysis used can be found in Bulletin 12 of the bureau.[3]

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[3] Frazer, J. C. W., and Hoffman, E. J., "Apparatus and Methods for the Sampling and Analysis of Furnace Gases." 1911. 22 pp.

METHOD OF USE.

The water-cooled tubes were inserted and the cooling water turned on before the cupola was charged. All of the tubes were inserted a distance that brought hole 1, or the hole nearest the inner end of the tube (Fig. 3), at the exact center of the cupola; hole 2, 4½ inches from hole 1 toward the lining; and hole 3, 4½ inches from hole 2 and 4½ inches from the lining.[4] This placing of the tubes divided the 13½ inches from lining to center into three equal parts. When the blast was turned on, the bubbling of the water in the wash bottles attached to the ends of the tubes gave evidence of the flow of gas. If the gas did not flow properly, the small tubes were disconnected at the point where they joined the lead tube and a wire was run through to remove the obstruc-

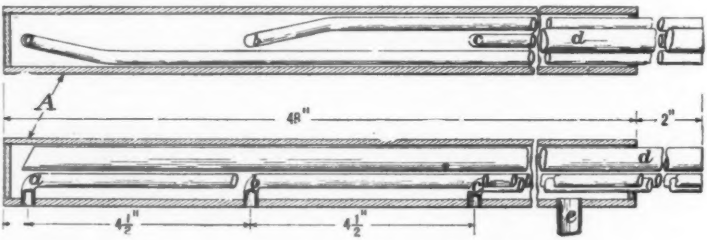

FIG. 4.—SECTION OF GAS-SAMPLING TUBE.

tion; or, as later practiced, compressed air was blown through from the end of the lead pipes. The latter procedure had the advantage of clearing the whole system and saved much time. After all the parts had been tested and gas was flowing freely, the mercury-filled sample receivers were attached. Fifteen minutes after the blast had been started the cocks on all the receivers were turned simultaneously and samples were taken for a period of 15 minutes. One set of three samples was taken from each imaginary horizontal plane, a total of 15 samples for each test. On several of the tests a sixth set was taken at a point above the charge, to show the average composition of the gases at that position. (See Pl. I, *A*.)

[4] The points in the fuel bed at the holes here mentioned are subsequently referred to in text and in tables as "locations."

Results of Analyses.

The results of analyses of the gases from separate tests, as well as the average for the series, are given in Table 1, as follows:

Table 1.—Analyses of Cupola Cases.

[L. L. Satler, Jr., analyst.]

Plane.[1]	Location No.[2]	Test No. — 1			2			3			4			5			Average.		
		CO_2	O_2	CO	CO_2	O_2	CO	CO_2	O_2	CO	CO_2	O_2	CO	CO_2	O_2	CO	CO_2	O_2	CO
A	1	5.9	0.0	25.1	8.8	0.0	19.5	17.1	0.7	4.9	16.8	0.3	6.0	11.6	0.0	15.5	12.0	0.2	14.2
	2	10.3	9.5	1.6	10.3	0.1	16.9	11.0	0.4	15.5	6.0	0.5	24.2	13.8	0.1	11.6	10.3	2.1	14.0
	3	1.1	19.6	0.0	2.5	18.1	0.0	3.1	17.6	0.0	9.5	10.6	1.1	7.3	13.1	0.3	4.5	15.8	0.2
B	1	7.9	0.0	21.3	15.6	0.5	8.3	12.2	0.0	14.0	14.0	0.0	11.1	15.6	0.3	7.5	13.1	0.1	12.4
	2	18.3	1.3	1.7	11.8	0.1	14.7	13.1	0.3	12.0	9.2	0.0	18.8	10.3	0.0	17.2	12.5	0.3	12.9
	3	10.4	10.1	0.1	14.0	6.2	0.7	8.1	12.4	0.0	12.4	7.8	1.1	12.7	7.8	0.4	11.5	8.9	0.5
C	1	7.0	0.0	23.2	13.9	0.2	10.9	12.9	0.0	13.1	11.7	0.0	14.7	14.1	0.5	10.1	11.9	0.1	14.4
	2	15.0	0.2	8.6	14.2	0.0	13.1	13.8	0.2	11.2	8.2	[3]0.7	19.7	....	....	....	12.8	0.1	13.2
	3	15.2	4.9	0.4	15.0	4.7	1.5	13.2	[3]7.8	0.5	16.6	2.8	1.2	15.1	4.8	1.4	15.0	4.9	1.0
D	1	6.3	0.0	24.0	11.3	0.0	15.3	10.8	0.0	16.3	9.1	0.0	18.9	11.4	0.0	15.8	9.8	0.0	18.1
	2	12.1	0.0	14.8	11.0	0.1	15.8	13.3	0.1	12.3	9.1	0.0	19.8	12.1	0.0	14.2	11.5	0.0	15.4
	3	17.6	0.7	4.1	17.0	0.7	4.9	16.9	[3]2.6	1.8	16.5	0.1	6.9	16.6	0.2	6.4	16.9	0.4	4.8
E	1	6.7	0.0	24.1	9.5	0.0	18.3	10.1	0.0	17.3	7.1	0.3	21.5	9.7	0.0	18.1	8.6	0.0	19.9
	2	10.6	0.0	16.6	10.4	0.0	16.7	....	....	....	8.5	0.0	19.1	10.9	0.0	16.0	10.1	0.0	17.1
	3	16.5	0.3	6.8	15.8	0.0	7.8	16.8	0.0	5.4	12.1	0.2	14.1	14.9	0.0	8.8	15.2	0.1	6.8

[1] Refers to imaginary horizontal plane, see pp. 12-13.
[2] Refers to holes in sampling tube, see p. 14.
[3] Probably due to channel flow of air; not included in average.

As was to be expected, samples of gas taken at different times showed many variations. The flow of the blast after entering the tuyeres was probably changing during the whole period, seeking escape inward as well as upward along the lines of least resistance. The largest volume undoubtedly flowed up the side walls, and this, as well as the part penetrating toward the center, was more or less deflected by the obstructions encountered. Effects of such changes were especially noticeable during preliminary work, when coke was charged in varying sizes as received. This explains why more uniform results are obtained in practice by the use of by-product coke or anthracite coal. During some of the first tests, in which large pieces of coke were used exclusively, oxygen persisted through the whole charge and was found

in the gas sample taken above the charge. This condition was no doubt due to the fact that the large pieces of coke against the wall allowed a free and practically unobstructed passage to a part of the gases. In the tests, the results of which are given in tables 1 to 5, all coke was broken into 3-inch cubes or less. The analyses of samples of the gases present above the charge under the conditions of the tests showed no oxygen, typical analyses being as follows:

ANALYSES OF GASES PRESENT ABOVE CUPOLA CHARGE.

[L. L. Satler, Jr., analyst.]

Kind of Gas.	Percentage of Gas in Location.[1]		
	1	2	3
CO_2	8.5	10.2	14.5
O_2	0.0	0.0	0.0
CO	20.6	17.8	8.4

[1] Explanation of locations given in footnote on p. 14.

DISCUSSION OF RESULTS.

Figs. 5, 6, and 7 have been constructed from Table 1. The planes of the cupola from which the gases analyzed were taken are represented as ordinates and the percentages of carbon dioxide, oxygen, and carbon monoxide as abscissas. Carbon dioxide (CO_2) is the product of complete combustion. Carbon monoxide (CO) is the product of incomplete combustion. The oxygen (O_2) of the blast entering at the tuyeres comes in contact with hot coke and the burning or combustion takes place, forming CO_2. This reaction produces heat and raises the temperature. If the CO_2 comes in contact with incandescent coke it takes up carbon from the coke and changes to CO. This reaction takes up heat and reduces the temperature.

GASES AT CENTER LINE OF CUPOLA.

Fig. 5, representing the conditions at the center line of the cupola, shows the practical absence of oxygen at all sections, the small quantity recorded being within the range of the prob-

able error of the method of analysis or attributable to the chance penetration of some small amount of the blast. The changes taking place in the first 6 inches show an increase of CO_2 and a decrease of CO, and from this point upward a rapid falling off of CO_2 and a corresponding increase of CO.

GASES 4½ INCHES FROM CENTER LINE OF CUPOLA.

Fig. 6 represents the conditions 4½ inches from the center and by the percentage of oxygen shown indicates the penetration of the blast at plane A. As shown in the figure, the percent-

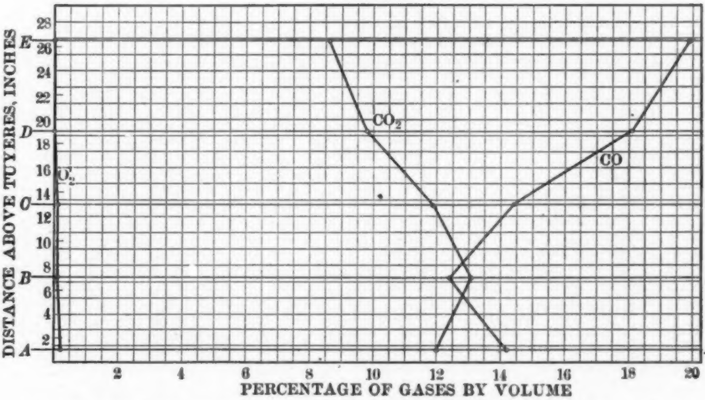

FIG. 5.—DIAGRAM SHOWING VARIATION IN PERCENTAGES OF O_2, CO, AND CO_2 AT DIFFERENT HEIGHTS (PLANES) ON THE CENTER LINE OF THE CUPOLA. LINES A, B, C, D, AND E REPRESENT THE IMAGINARY PLANES.

age of oxygen rapidly decreased, being practically nothing 6 inches above, at plane B. Comparing the conditions at the center and 4½ inches from the center as represented in the figures, the CO_2 percentages in both cases show the same general increase through the first 6 inches. At 4½ inches from the center there is no material change during the movement through the second 6 inches. From this point upward through the fuel bed the percentage of CO_2 at 4½ inches from the center decreases but not so rapidly as the percentage at the center. The CO percentage 4½ inches from the

center decreases in the same general manner as the CO at the center during the passage of the gases through the first 6 inches. Through the second 6 inches no material change takes place. From this point up through the bed the proportion of CO at 4½ inches increases, but not so rapidly as that at the center.

GASES 9 INCHES FROM CENTER LINE OF CUPOLA.

Fig. 7 represents the conditions 9 inches from the center and 4½ inches from the lining. One inch above the tuyeres the oxygen of the blast is reduced by an amount necessary to form

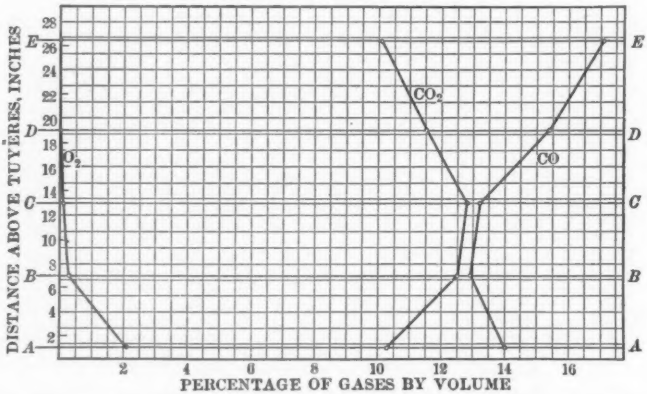

FIG. 6.—DIAGRAM SHOWING VARIATION IN PERCENTAGES OF O_2, CO, AND CO_2 AT POINTS 4½ INCHES FROM THE CENTER OF THE CUPOLA. LINES *A*, *B*, *C*, *D*, AND *E* REPRESENT THE IMAGINARY PLANES.

4.5 per cent CO_2, and the formation of CO_2 rapidly increases in the first 6 inches, with corresponding decrease in O_2 and with little formation of CO. These conditions indicate a fierce burning and a great rise in temperature. This assumption is borne out by the rapid rise of the temperature at plane *B* as compared to the temperature at plane *A*. (See also Fig. 15.)

From plane *B* the oxygen rapidly decreases to practically nothing just above plane *D*. The CO_2 remains practically constant from plane *B* to plane *C*, the CO increasing slightly. During

the passage of the gases through the next 6 inches both CO_2 and CO increase. This zone of highest CO_2 content, as yet not materially affected by the rise of CO, is the hottest part of the entire fuel body. This condition is also indicated in Fig. 15. From this point to the next plane (*E*) 7½ inches above, the CO_2 decreases and the CO increases. The temperature decreases.

The temperature conditions at plane *E* and at plane *C* are nearly the same, but the conditions for melting are materially different. At plane *C* there is a supply of oxygen that would

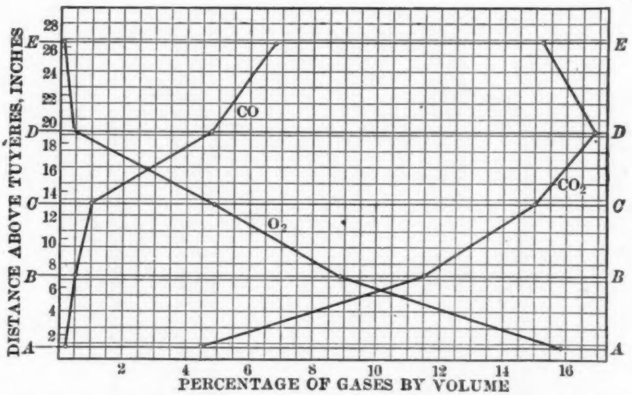

FIG. 7.—DIAGRAM SHOWING VARIATION IN PERCENTAGES OF O_2, CO, AND CO_2 AT POINTS 9 INCHES FROM THE CENTER AND 4½ INCHES FROM THE LINING OF THE CUPOLA. LINES *A*, *B*, *C*, *D*, AND *E* REPRESENT THE IMAGINARY PLANES.

undoubtedly cause oxidation of the metal and resultant loss. Whether the amount of iron melted at this plane would be oxidized sufficiently to affect seriously castings made from the whole tonnage was not determined by these investigations, but if certain conclusions, based on the tests at St. Louis,[5] as to the effect of burned metal on casting are correct, it is safe to assume that the chances favor the production of defective castings.

[5] Moldenke, Richard, "The Coke Industry of the United States as Related to the Foundry." Bull. 3, Bureau of Mines, 1910, p. 19.

PROBABLE COMBUSTION AREA.

The broken line in Fig. 8 represents the upper boundary of the region of gases containing free oxygen.

As indicated in Fig. 8, the actual combustion of the fuel takes place in the fuel bed around a region having the shape of an inverted cone; the apex of this cone is at the center on the level of the bottom of the tuyeres and its surface flares out to the lining at a point 20 inches above. If melting be kept above the base of this cone, no oxidation will occur.

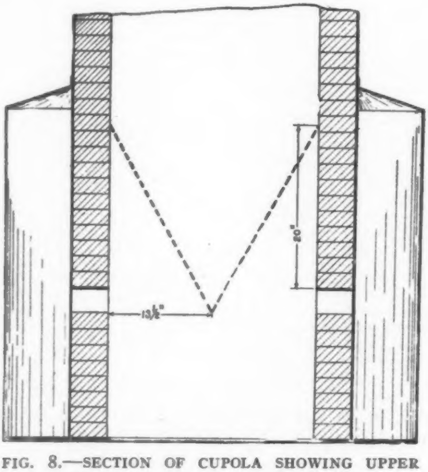

FIG. 8.—SECTION OF CUPOLA SHOWING UPPER BOUNDARY OF REGION OF COMBUSTION.

PROBABLE LINE OF HIGHEST TEMPERATURE.

Considering the region of gases highest in CO_2 content and devoid of O_2 (see Figs. 5, 6, 7, and 8), and considering the plotted line of highest CO_2 content at each plane as a line of demarcation, the line *ab* in Fig. 9 shows in cross section the probable shape of the top of the fuel bed as defined by the points of highest temperature.

If it were possible so to charge the cupola that melting would take place along or just above such a line (or, rather, surface) as is indicated in this figure, ideal results would be obtained both

as regards temperature and absence of oxidation. Since it is not possible to confine the melting to this irregular region, the best condition for melting is obtained at that section across the whole of the fuel bed that shows the highest temperature together with absence of oxygen. This condition, as shown by the tables of temperatures and of analyses of the gases, exists just above plane D, about 20 inches above the tuyeres. It is not possible to do all melting at this particular plane, but the melting can be so confined and regulated that none takes place below this plane.

The height of the melting zone above this plane is deter-

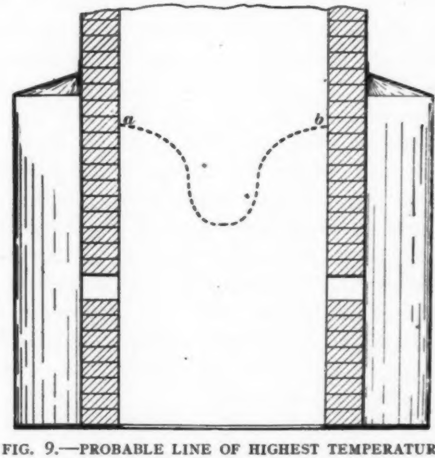

FIG. 9.—PROBABLE LINE OF HIGHEST TEMPERATURE.

mined by the physical condition of the coke and the rate of heat absorption of the iron. If the coke is porous, the charges of iron should be small to prevent the coke burning out and letting the iron down into the oxidizing zone before melting is accomplished. If the coke is heavy and dense, or if anthracite coal is used, the charges may be made larger, as the fuel will burn more slowly and give a longer time for melting. In some region above this zone of highest temperature the temperature is still high enough to melt iron but is not high enough to impart heat quickly and to give hot iron. This melted iron passes through the lower zones, although the temperature in these zones be exceedingly high,

too rapidly for the absorption of enough heat to raise its temperature materially, and cold iron is the result. The experiments here reported confirm the general opinion that the hot test part of the cupola is where the lining is most burned out. A curved line drawn to represent the burned-out lining corresponds closely with the curves drawn to represent the heat absorbed at the several planes previously described.

Alteration of Cupola Lining.

A study of the data shown in Table 1 led to the conclusion that the amount of coke necessary for melting could be reduced by changing the lines of the cupola from the straight to the boshed form. Accordingly the lining was drawn in to 23 inches at the tuyeres, tapered to the original lines of 27 inches at 15 inches above the tuyeres, and continued straight from this point. It was thought that the blast entering at the tuyeres would penetrate farther toward the center of the cupola and a smaller volume of air would escape up the side walls without first coming in contact with hot coke. This, it was hoped, would cause the loss of all the oxygen at a lower point in the fuel bed and would lower the zone at which the iron could be melted without its quality being seriously affected. The zone of highest temperature was expected to follow the zone where oxygen disappeared, as in the case of the straight lining, but no attempt was made to determine whether this relation held.

RESULTS OF ANALYSES OF GASES FROM CUPOLA OF BOSHED CONSTRUCTION.

Table 2 shows typical analyses of gases sampled after alteration of the lining but taken from the same locations as were the gases whose analyses appear in Table 1. Table 2 follows.

The penetration of oxygen was affected, as may be seen by comparing the analyses with those of Table 1, but the oxygen persisted up through the whole bed. The analysis of the gas at the point represented by D3 of the table shows 3.3 per cent O_2, as compared with 0.4 per cent at the corresponding location with the original straight lining (Table 1). The drawing in of the lining materially increased the blast pressure (from 3.6 to 5.5 ozs.)

and the flow of gas was accelerated to such an extent that the time of contact with the coke was not sufficient to rob the blast of its oxygen.

Temperatures.

DIFFICULTIES OF MEASUREMENT.

Measuring temperatures in the fuel bed of the cupola presents many difficulties and all attempts to get actual temperatures

TABLE 2.—ANALYSES OF GASES FROM CUPOLA OF BOSHED CONSTRUCTION.

[L. L. Satler, Jr., analyst.]

Plane.	Location No.	Percentage of		
		CO_2	O_2	CO
A	1	11.1	1.0	14.3
	2	0.3	20.4	0.0
	3	0.2	20.7	0.0
B	1	14.8	1.2	8.4
	2	11.1	9.3	0.0
	3	2.2	18.4	0.0
C	1	14.6	0.0	10.6
	2	16.0	4.0	0.7
	3	5.4	15.2	0.3
D	1	10.3	0.0	17.3
	2	15.7	0.0	8.0
	3	16.9	3.3	0.7
E	1	7.5	0.0	21.9
	2	13.2	0.0	12.5
	3	17.1	0.5	4.7

failed. Descriptions of the several forms of apparatus used in the various tests here reported are given somewhat in detail for two purposes: (1) To draw attention to the many difficulties encountered during this part of the investigation, and (2) to render these experiments more serviceable to future investigators. Diligent search of all available literature failed to reveal accounts of attempts to determine the actual temperature in the interior of the fuel bed of the cupola or in other metallurgical operations

on the same scale. Measurements have been attempted at points on or near the furnace walls, but not at points over a considerable cross-sectional area.

Use of Platinum-Rhodium Thermocouples.

It was first decided to take temperatures by means of platinum-rhodium thermocouples introduced into the fuel bed through clay tubes, as shown in Fig. 10. The thermocouples were so placed that readings were obtained at the center of the cupola (*a*, Fig. 10), at a point 4½ inches from the center toward the lining (*b*, Fig. 10), and at a point 9 inches from the center and 4½ inches from the lining (*c*, Fig. 10). The positions of the

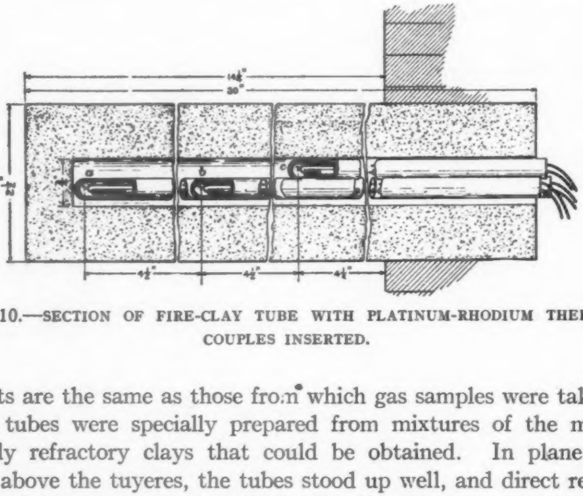

FIG. 10.—SECTION OF FIRE-CLAY TUBE WITH PLATINUM-RHODIUM THERMOCOUPLES INSERTED.

points are the same as those from which gas samples were taken. The tubes were specially prepared from mixtures of the most highly refractory clays that could be obtained. In plane *A*, just above the tuyeres, the tubes stood up well, and direct readings of temperature were obtained. Readings over 15-minute periods, taken each minute, showed an average temperature of 2593° F., 2430° F., and 1576° F., at points represented by *a*, *b*, and *c* of Fig. 10; the maximum variation at any one point was 122° F. Above plane *A* the tubes were sheared off at their point of entrance through the wall by the movement of the charge. To prevent this shearing a pier of magnesite brick was constructed to support the ends of the tubes. Although the pier prevented

shearing, it was of no avail in obtaining readings, as the clay tubes were melted at all planes above plane *B*. At the center of the cupola in plane *B* the thermocouple was melted, indicating a temperature above 3100° F. As a result of these tests, the use of the platinum-rhodium thermocouples was abandoned.

Use of Optical Pyrometer and Water-Cooled Tube.

The next step was an attempt to obtain temperatures with an optical pyrometer by observation through a water-cooled iron tube with a glass-covered opening at one end. A cross section of the tube is shown in Fig. 11. It was fully appreciated that the readings obtained would not represent actual temperatures on account of the cooling effect of the water-cooled tubes, but

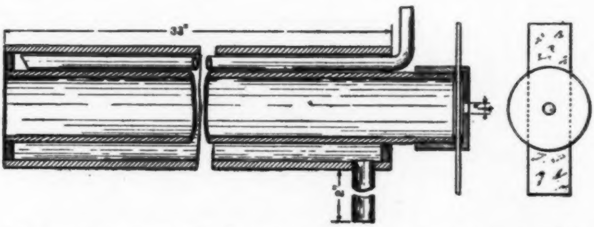

FIG. 11.—SECTION OF WATER-COOLED IRON TUBE USED IN TAKING TEMPORARY READINGS.

it was hoped that approximate temperatures showing the temperature differences between planes would be obtained and that they could be expressed in degrees of temperature with an explanation as to the limitations of the method. It was thought that at any given point the highest reading obtained during the whole period of the test would approximate the true temperature at that point. However, the averages of five temperature readings made at each of five points at different heights on a vertical line at the center of the cupola proved to be practically the same as were the highest temperature readings at each of the points. It was thought that the true temperatures at the center of the cupola might possibly be as uniform as these readings indicated, since no analysis of the gases taken at any time showed an appreciable amount of oxygen, and therefore indicated that there was

no combustion. Further tests with the ends of the tube at varying distances from the side wall continued to show for all points in any vertical line practically the same average temperature and the same high temperature. It was thought that this condition might be due to the fact that the ends of the water-cooled tubes were in direct contact with the coke.

Use of Clay Protecting Tips.

With the hope of further perfecting the apparatus, a clay protecting tip (Fig. 12) was placed over the end of each of the water-cooled tubes, extending a distance of 2 inches. This made possible the reading of the temperature of coke that was not in direct contact with the water-cooled tubes. These protecting

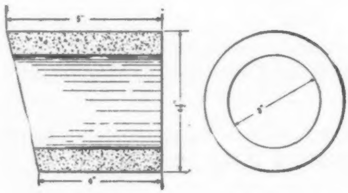

FIG. 12.—SECTION OF CLAY PROTECTING TIP.

tips were melted, like the clay tubes, but held up long enough to show the same uniform readings as with the unprotected tubes.

Discussion of Results.

Tables 3 and 4 show typical readings of temperatures taken through water-cooled tubes with an optical pyrometer. The tables follow.

Use of Water-Cooled Copper Tube.

The tube shown in Fig. 13 was finally adopted as a device for determining the amount of heat absorbed per minute at different depths in the fuel bed. A $\frac{3}{4}$-inch copper tube 32 inches long was closed at one end by welding in a circular piece of steel. A $\frac{1}{4}$-inch tube inserted at one end and extending to the farther end provided a means for circulating water through the tube.

This tube was inserted different distances into the fuel bed and the heat absorbed by a measured quantity of water during a

TABLE 3.—TEMPERATURES, °F.[1].

Plane. A	B	C	D
2,736	2,827	([2])	2,827
[3]2,862	([2])	([2])	([2])
2,653	2,966	2,934	2,786
2,712	([2])	3,015	2,741
2,736	3,036	2,988	2,692
([2])	[3]3,083	([2])	([2])
2,742	2,939	[3]3,052	[3]2,961
2,800	2,811	3,009	([2])
[4]2,750	[4]2,942	[4]3,000	[4]2,802

[1] All temperatures taken at center of cupola with Wanner optical pyrometer at intervals of 2 minutes.
[2] Cold; not included in total. [3] Maximum. [4] Average.

TABLE 4.—TEMPERATURES, °F.[1]

Plane. A	B	C	D	E
2,584	[2]3,027	2,993	2,579	2,856
2,763	2,939	[2]3,020	2,674	2,786
2,988	2,809	2,925	2,871	2,696
3,020	2,804	2,851	2,570	2,763
2,826	2,971	2,809	2,856	[2]2,914
[2]3,067	2,752	2,687	[2]2,908	2,883
3,060	2,817	2,809	2,826	2,800
2,939	2,773	2,593	2,692	2,800
3,033	2,678	([3])	2,766	2,817
2,671	2,790	([3])	2,874	2,680
2,790	2,955	2,851	2,889	2,797
2,899	2,851	2,674	2,719	2,755
2,934	2,817	([3])	2,730	2,851
[4]2,890	[4]2,845	[4]2,822	[4]2,766	[4]2,800

[1] All temperatures taken at center of cupola with Wanner optical pyrometer at intervals of 1 minute; 2-inch clay protecting tips on ends of water-cooled tubes.
[2] Maximum. [3] Cold; not included in total. [4] Average.

definite period of time was determined. The flow of water was kept as nearly constant as possible. The average amount for each test was 150 pounds in all, or 10 pounds per minute. The

temperature of the inlet and outlet water was obtained by means of mercurial thermometers. Readings of the temperature of the inflowing and outflowing water were made each minute during a test. These readings were separately averaged. The

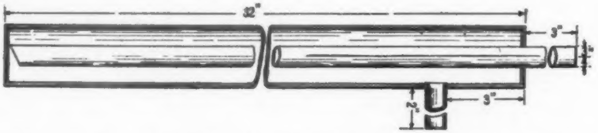

FIG. 13.—SECTION OF WATER-COOLED COPPER TUBE USED FOR DETERMINING AMOUNT OF HEAT ABSORBED PER MINUTE AT DIFFERENT DEPTHS OF THE FUEL BED.

difference between the average temperatures over a definite period multiplied by the total weight of water circulating through the tube during that period gives the total heat absorbed. This

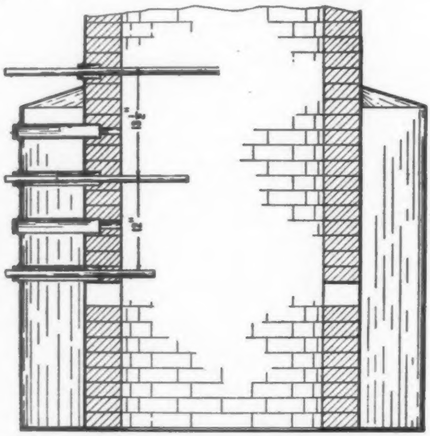

FIG. 14.—SECTION OF CUPOLA SHOWING LOCATION OF WATER-COOLED COPPER TUBES.

total divided by the total number of minutes of the test gives the heat absorbed per minute. Fig. 14 shows how the tubes were placed in the cupola. The copper tubes were thoroughly cleaned before each test and the conditions were made as uniform

as possible in all respects. Only two tubes were used during any one test. They were placed at least 12 inches apart in order to prevent a possible reduction of temperature by radiation of heat from coke surrounding one tube to the other tube if the two were in close proximity. Plate I, *B*, shows details of apparatus as used for determining the heat absorbed.

Results with Use of Water-Cooled Copper Tubes.

Table 5 shows the heat absorbed per minute at the different planes. The tubes were inserted in the fuel bed to distances corresponding with the points from which the gas samples were taken. For location 1 of the table the tube was inserted 13½ inches (from the lining to the center of cupola); for location 2, 9 inches; and for location 3, 4½ inches. Table 5 follows:

Table 5.—Heat Absorbed per Minute at Different Locations in the Fuel Bed, B. t. u.

Plane.	Location.	Length of tube exposed, inches.	Test No. — 1	2	3	4	5	6	Average.
A	1	13½	347.8	304.0	351.2	311.8	292.4	399.4	334.4
	2	9	191.1	161.7	163.3	222.3	199.3	189.5	187.9
	3	4½	20.4	19.5	38.2	21.4	27.7	22.6	25.0
B	1	13½	495.1	506.0	594.1	514.5	559.0	534.5	533.9
	2	9	339.4	344.9	363.1	315.7	343.2	385.1	348.6
	3	4½	158.8	131.4	144.0	118.9	155.1	128.6	139.5
C	1	13½	612.0	615.0	.....	541.3	545.9	625.2	587.9
	2	9	362.2	399.0	450.2	457.5	456.8	460.3	431.0
	3	4½	110.3	178.5	186.1	189.8	220.1	238.7	187.3
D	1	13½	598.5	.....	606.4	623.3	582.7	651.4	612.4
	2	9	453.3	466.3	449.4	472.0	432.6	449.0	453.8
	3	4½	238.9	242.3	229.6	236.8	243.9	.....	238.3
E	1	13½	613.8	587.7	558.6	572.5	609.0	614.5	592.7
	2	9	400.8	425.3	407.0	401.0	401.6	386.1	403.7
	3	4½	244.0	242.1	255.0	202.7	248.1	.....	238.5

The heat measurements by the copper tubes show the heat absorbed by the tubes over the whole distance to which they were inserted and not the heat at some particular point in the fuel bed. As in the case of the gas analyses, the observations

varied considerably. Allowance being made for the crudeness of the method, the variations are not surprising.

GRAPHIC REPRESENTATION OF RESULTS.

Figs. 15 and 16 show graphic representations of the results.

AVERAGES.

Fig. 15 gives a graphic representation of the averages of the observations at each location, which are believed to show the relative temperatures of the several planes measured. The heat absorbed per minute is shown as abscissas and the heights

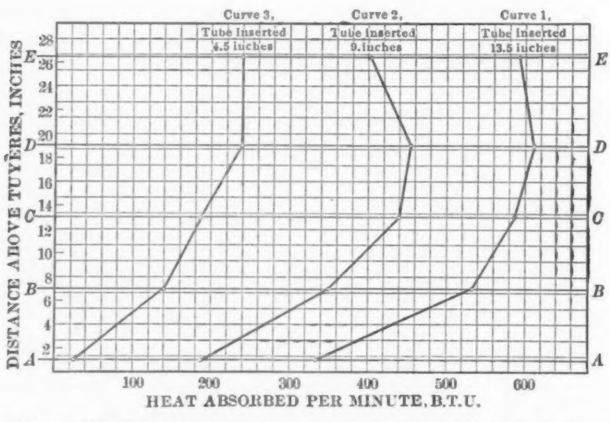

FIG. 15.—DIAGRAM SHOWING THE VARIATION IN NUMBER OF BRITISH THERMAL UNITS ABSORBED AT DIFFERENT HEIGHTS (PLANES) IN THE FUEL BED. LINES *A*, *B*, *C*, *D*, AND *E* INDICATE THE IMAGINARY PLANES.

(planes) as ordinates. From this figure it will be noted that the greatest amount of heat was absorbed at plane *D*. At plane *A*, with tube inserted $4\frac{1}{2}$ inches, the cooling effect of the blast is evident, the heat absorbed being small. As the height above the tuyeres increases the temperature steadily increases up to plane *D*. Curve 1, representing the heat absorbed in each section when the tubes were inserted over the whole radius of the cupola, shows that the height above the tuyeres where the greatest heat existed over the whole cross section of the fuel bed was at *D*, 19 inches above the tuyeres.

EFFECT OF LOCATION.

The heat absorbed in each plane of the cupola is shown by the curves in Fig. 16. The figures representing the heat absorbed in the first $4\frac{1}{2}$ inches from the lining are direct determinations.

The figures for the second $4\frac{1}{2}$ inches are obtained by deducting the amount found for the first $4\frac{1}{2}$ inches from the amount found for 9 inches, and for the third $4\frac{1}{2}$ inches by subtracting the amount found for the 9 inches from the total for the whole $13\frac{1}{2}$ inches. In the zone between the lining and a line $4\frac{1}{2}$ inches within, the temperature increased rapidly through the lower 19 inches. Through the next $7\frac{1}{2}$ inches it was practically unchanged.

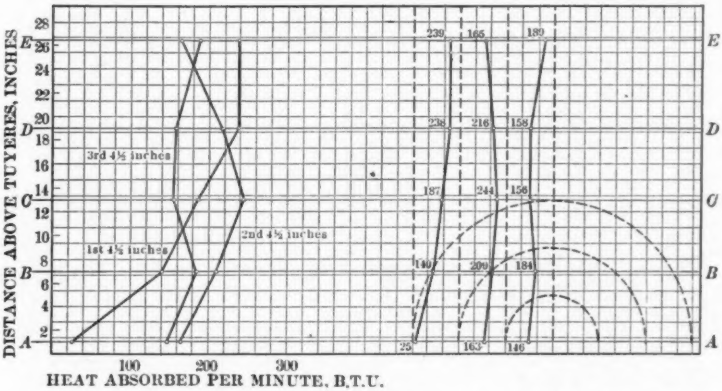

FIG. 16.—DIAGRAM SHOWING VARIATION IN AMOUNT OF HEAT ABSORBED PER MINUTE IN DIFFERENT REGIONS OF CUPOLA FUEL BED.

A comparison with the gas curve shown in Fig. 7 shows that the temperature followed the increase of CO_2 to plane *D*, 19 inches above the tuyeres. Through the next $7\frac{1}{2}$ inches the CO_2 fell off though the temperature was constant, the amount of CO formed seemingly not absorbing enough heat to reduce the temperature. In the region included between lines $4\frac{1}{2}$ and 9 inches distant from the lining the temperature increased to plane *C*, 13 inches above the tuyeres and fell off from this point upward. This temperature curve, when compared with the gas curves presented in Fig. 6, shows that the increase of heat followed the increase of CO_2 up to plane *C*; then fell rapidly through the next two planes as

the CO rose. In the third region, included between lines 9 and $13\frac{1}{2}$ inches from the lining and representing the central part of the cupola, the temperature rose through the first 6 inches, fell off through the second 6 inches, remained constant through the next 6 inches, and finally increased rapidly through the last $7\frac{1}{2}$ inches. Comparing this curve with the gas curves of Fig. 5, the temperature curve is found to follow the CO_2 curve through the first 12 inches. From this point up through the remaining $13\frac{1}{2}$ inches of the fuel bed, the temperature would be expected to fall considerably since the CO_2 decreases and the CO increases. The actual determination of the heat absorbed shows the reverse to be true. The rapid change of CO_2 to CO absorbed heat and cooled the central part of the cupola below the surrounding portions. The flow of heat from the hotter to the cooler portion increased the temperature of this central part.

As it was not possible to make true temperature measurements at the several points corresponding with the points from which the gas samples were taken, it is not possible to confirm the probable location of the points of highest temperature as shown in Fig. 9. However, by the use of the curves shown in Fig. 15, it is possible to confirm the conclusion that the best melting zone is where the highest temperature and an absence of oxygen exist throughout the whole cross section of the fuel bed. An examination of the curves shows that the region of highest temperature corresponds with that region where oxygen is entirely absent across the whole cross section. This region is about 19 inches above the tuyeres.

Conclusions.

The ideal melting region probably corresponds to that lying along and just above the line *ab* of Fig. 9. This line includes points in the figure representing those points in the cupola having highest carbon-dioxide content together with an absence of oxygen, as determined from analysis of the gases. It is manifestly impossible to confine melting to such a region, and the logical conclusion from the experiments here reported is that the best results are obtained if the iron is melted at that region in the cupola where the highest temperature, together with an absence of oxygen, exists across the whole fuel bed. The bottom of this

region in the cupola tested was 19 inches above the tuyeres when 1,000 cubic feet of air per minute was being blown. This region will be raised if the blast is increased and be lowered if the blast is reduced. Experimental determination of this region is not necessary. In practice, the bellying out of the lining of the cupola is a perfect index of the position of the melting zone, and this bellying is in the region where temperature is highest and oxygen is absent.

Care must be taken not to melt below the bottom of this region, for, the oxygen of the blast not being entirely removed, the iron will be oxidized or burned. The extent of this burning is dependent on the distance below the proper melting region and the lateral position in the fuel bed. Just below the bottom of this melting region oxygen is still found at the lining and the cross-sectional area of this oxidizing region increases as the distance downward increases until the whole cross section at the tuyeres shows the presence of this damaging element. The whole problem of obtaining hot iron, free from effects due to oxygen, is solved by using small charges evenly distributed on the fuel bed,[6] and confining the melting to a few inches above the plane shown by the burning out of the lining to be the hottest plane of the fuel bed. If the first charge of iron is so placed that melting begins, say, 4 or 6 inches above this plane and is completed before any of the iron gets below it, and if the following coke and iron charges are so regulated as to maintain this melting zone, the best possible results will be obtained.

The experiments here reported indicate further that the use of upper tuyeres is not only unnecessary but a positive detriment to the production of the best iron. The introduction of air into the fuel bed above the tuyeres, even though in small volume, increases the liability of injurious effect from oxygen and serves no useful purpose. The increased tonnage supposed to be obtained by the use of upper tuyeres can be produced just as easily by blowing through the bottom tuyeres the proper volume of air.

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[6] Moldenke, Richard, "The Coke Industry of the United States as Related to the Foundry." Bull. 3, Bureau of Mines, 1912, p. 22.

FOUNDRY TRAINING IN THE HIGHER TRADE SCHOOLS.

Review and Comparison of German and American Foundry Schools.

By Dr. Otto Brandt,
Secretary, German Foundrymen's Association.

In Abstract and Translation.

By P. Kreuzpointner,
Chairman, American Foundrymen's Association Committee on Industrial Education.

Dr. Otto Brandt visited many of our schools and colleges—as also those of England—in the fall of 1912, in order to acquaint himself with the training given to young men for the Foundry. He published a review under the title above given in the March number of the official organ of the German Foundrymen's Association.

For a better understanding of the German system of industrial schools it may be stated at the outset that they have a variety of schools preparing young people for a given vocation up to a given degree of efficiency.

Grades of Schools.

Every boy in Germany, no matter what his occupation is, must go to some kind of a school from fourteen to eighteen years of age, unless he is attending some preparatory school for college. If the boy does not go to work at fourteen he must attend for three years a so-called Continuation School in which there is a repetition, or continuation, of the elementary subjects of the school. If the boy goes to work at fourteen he must attend an industrial continuation school, to which his employer must send him on

week-days during day time. In these industrial continuation schools subjects are taught which pertain to the occupation of the boy, but on which he receives no instruction in the shop while he is at work. Thus the school instruction supplements the shop instruction.

Then there are the lower and higher technical schools for those who wish to become foremen, or to fit themselves for some kind of managerial position below the engineering grade.

German Foundry Schools.

Most of the existing foundries are part of a metal industry of some kind, and therefore those working in the foundry are employees of the general business. The training for the foundry work must therefore share its time and opportunities with the other departments.

The same situation is found in the lower and higher technical schools, where foundry work is part of the work of a course for machine builders. Thus, in the course of study, where several branches of learning have to be taken care of, the foundry work receives its share with the rest of the other subjects.

Comparison between Germany and America.

In making comparison between the relative value of German and American foundry training, Dr. O. Brandt comes to the conclusion that after all we are not so badly provided for in facilities for training foundry foremen and such other high class help around the foundry which requires not only manual skill but also more or less technical and business knowledge in addition to executive qualities.

Dr. Brandt makes favorable mention of the foundry school at Purdue University, at Wentworth Institute at Boston, at the Carnegie Institute of Technology and at the Technical High School at Birmingham, England, devoting considerable space to their detailed courses.

Summary.

In summing up the results of his investigation Dr. Brandt says there is more or less provision made to enable the bright,

industrious and ambitious young man to acquire a leading position in the foundry trade. However, the American and English schools do not all serve that purpose.

There are schools for apprentices, and these must be considered also since in the United States trade education is not so systematically organized as in Germany, and in the lower apprentice schools of the United States undoubtedly some young men find opportunity to rise to the top. He also thought it desirable to mention those schools in which foundry work forms only a necessary adjunct to engineering—or machinery trade education, in order to make his investigation complete.

But these schools do not fulfil the aim and purpose we are pursuing. What is needed most now are specific foundry trade schools, separate and distinct for themselves, low enough upon the one hand to serve as preparatory schools for the foundry apprentice, and high enough upon the other hand to serve as preparatory schools for leading positions in the foundry industry.

The study of American and English schools offers much that is instructive and valuable in comparison with German schools. One cannot fail, however, to note how well and strongly German schools are organized and systematized, able to give an excellent account of their activity whenever they remain within the limits of their basic aim. This aim is to furnish practical men for the trade. This they do when not carried away by the ambition to educate engineers. For this they are not fitted and only increase the army of low grade technical men who crowd into the draughting rooms, because they consider themselves too good for the shop, thus leading an existence of dissatisfaction with themselves and their surroundings.

Much could be done to minimize or prevent this condition in planning the course of study, and to lay the emphasis of the aim of the school to be for service in the shop.

German Examples.

In the fore part of his discussion Dr. Brandt says that schools for the machine industry do not contribute much toward the specific training for the foundry industry: with them the foundry is only an auxiliary. In a school for the machine industry only one-fifth of the time allotted to technological subjects was given

to the foundry. Nevertheless, much benefit is derived by the foundry industry as revealed on inspecting the results of their examination papers.

As an example we may take the school for the machine industry at Stetin. One of the theses of this school embraces the following points:

1. A foundry is to increase its productive capacity. In the iron foundry department four new modern cupolas are to be installed. Two of these are to be used for light castings and two for heavy castings. Each of these cupolas is to be illustrated by sketches, their advantages and disadvantages are to be described and estimates of the individual cupolas are to be submitted. New blowers are also to be installed and descriptions and estimates are to be furnished for these also.

For the Roll Foundry department a new Open Hearth furnace is to be built. Estimates are to be submitted with particular reference to the system recommended. The brass foundry is to have a new crucible furnace for which estimates are to be submitted. The report is to be formulated as if it were a set of specifications accompanying a bid for the contract.

2. A machine factory proposes to enlarge its foundry by an additional department for mass production with molding machines. A bid is to be submitted giving sketches and descriptions of the individual machines, their capacities and manner of operation. In the smith shop a new forging press, with accumulator, is to be installed. Specifications are to be submitted with the bid in a similar manner.

3. Various methods for the production of spur gears are to be described. A normal spur gear of twenty-eight teeth is to be cast and finished. Drawings, illustrating the various steps taken in producing the work, including the tools used, are to be made. Of the machines used in doing the work only those parts are to be shown which were in actual use during the production of the work.

4. Description of the details of making the mold for the steam cylinder shown in the drawings. Full size drawings of the pattern for the cylinder; the thicknesses of the walls of the cylinder are to be shown in cross section. The core boxes for the cylinder. Slide valve and steam channels. The finished mold.

Those parts of the mold which are not visible are to be illustrated by sketches.

At another school we have noticed the following examination subjects:

Molding, casting and finishing of a roll; pattern and templet of a pulley, and molding of the same; how to make cores by machinery; producing cast iron pipes and columns; samples of molding of pattern; chilled castings, steel castings and malleable castings; furnaces in the foundry.

Without doubt, the students of the machine industry schools receive more instruction in foundry practice than do the students at the engineering universities.

Technological Subject in Schools for the Machine Industry.

Higher schools: first and second year, 10 hours weekly; third and fourth year, 2 hours weekly. Laboratory work: second year, 2 hours weekly; third and fourth year, 4 hours weekly.

Lower schools: second year, 5 hours weekly; third year, 10 hours weekly; fourth year, 4 hours weekly. Laboratory work: second year, 2 hours weekly; third and fourth year, 4 hours weekly.

Subjects.—Production of iron and steel: Chemistry of iron, iron ore, coke, blast furnace, puddling—Bessemer—Open hearth process; crucible steel, electric steel. Rolling of shapes, and sheets. Drawing of wire and pipe. Production of copper, lead, zinc, tin and aluminum. Foundry work: Materials for molding. Shrinkages and stresses in castings. Patterns. Hand molding. Machine molding. Core making. Templet molding. Drying of molds. Metals and alloys used in the foundry. Cupolas and Furnaces used in the foundry. Drying of molds. Cleaning of castings.

Remarks by the Chairman of the Committee on Industrial Education.

Leaving out of consideration the graduates of our colleges whose training fits them chiefly for managerial positions, we can fairly compare the above mentioned machine industry schools with our higher grade technical high schools, although there is a dif-

ference in organization. First there is noticeable a great difference in the number of schools of a grade analogous to those German schools with an auxiliary foundry course and a complete course of technological subjects such as those mentioned by Dr. Brandt. Prussia alone has twenty-three of such schools and while not all of them do practical foundry work, their technological course never fails to include metallurgical processes which are closely related to the foundry. In our own schools emphasis is laid upon the practical part of the work and a minimum of time is devoted to the related technical subjects pertaining to the foundry and pattern making.

Of forty schools of all kinds, making any pretense of teaching something of the machinist trade, only twelve have foundries of some sort, sometimes only enough to make some superficial demonstrations of founding in white metal. In some schools the foundry course, of what there is, is optional or, as stated in one case, "indefinite."

In the best of our schools the technological part receives but little attention. Even where desired, the lack of sufficiently trained teachers in schools of less than college grade, would effectively prevent entering into a study, to any account, of technological subjects related to the foundry.

But it is this grade of schools upon which the foundry industry of this country must depend more or less for prepared help for its shops, and this preparation cannot be had without the foundrymen putting their shoulders to the wheel and helping to raise our industrial schools and teachers to a higher level of efficiency.

The ambitious tendency to consider technical training of a low grade fit for engineers' service is even stronger with us than in Germany.

GRAY IRON FOR MOTOR CAR CASTINGS.

By H. B. Swan, Detroit, Mich.

The subject of cast iron as related to motor cars covers a much wider field than the scope of this paper will permit. Cast iron and steel are the materials which are by far the most extensively used in the mechanical parts of the car, although malleable iron does enter into consideration to no small extent. Such a vast amount of research work has been done on steel that the selection of a composition chemically and physically most suitable for the kind of service demanded of it is no longer a matter of guesswork. Perhaps not to the same degree but still vastly important is the selection of the proper composition of metal most suitable to meet the duties required of the parts made from cast iron.

The building of motor cars has become a science and the automobile engineer demands castings of a maximum strength with a minimum of weight. The design of the part may be of such intricacy as to produce conditions which tend to cause defective castings. He further specifies that the castings shall conform within limits to a certain chemical composition and be free from the numerous characteristic foundry defects. Moreover, the machine shop demands that they shall cut readily. This does not necessarily mean that the castings shall be soft, although metal too hard or having hard spots is bad for machining. In the opinion of the writer there is a discrimination between hardness and cutting qualities, judged from the standpoint of the life of the tool.

It is the practice in the foundry with which the writer is associated to pour several test bars of each kind of iron daily. These test bars are ½ inch square and represent to a fair degree a section of the castings made, and are used in connection with Keeps' test. After being broken for transverse strength they are ground to a smooth surface and tested with a Brinell machine for

hardness. It has therefore been a matter of careful observation and interest to note that while the chemical composition and hardness as represented by these daily test bars may not vary to but a slight extent, cutting qualities of the iron seem to fluctuate materially. As a usual thing the amount of combined carbon present gives a good indication of the hardness of the metal, but inasmuch as experience has shown us that the metal may be hard to machine, that is, hard on the tools even when the combined carbon is present only in a normal amount or less, it seems that there must be other factors to consider. Is it not possible then that the crystalline structure may have something to do with the machinability of the metal?

Since the machine shop operations are usually on a piecework or premium system, the importance of keeping the quality of the metal uniform is readily understood, for if the metal is hard uniformly or has hard spots, or, as said above, is hard on the tools, it means a slowing up of production and a loss of both time and money to the manufacturer and the foundryman.

Let us consider some of the motor parts made from gray iron. For many reasons the cylinder has been most widely discussed. Often it is of a very complex design. It may be cast as a single unit with or without a water jacket. Twin cylinders are common and three, four and even six en bloc are met with frequently. Of late it has come into practice to cast the cylinders en bloc integral with the engine base and even more complex designs are not uncommon. Under such conditions very light sections join with those comparatively heavy and it is not an easy matter to select an iron of a composition that will run well, be sound and free from spongy spots, leaks, etc., and meet other requirements. Another matter to consider is the wearing qualities of the iron. This is something which as yet seems to have been given little study and attention. Some work has been done in Europe in connection with bronzes with the aid of a machine especially designed for this purpose. It would seem, for instance, that it would be not only interesting, but of value, to know more about the relation between the cylinder and the piston ring in connection with their wearing qualities, hardness and chemical composition. The laboratory of the company by whom the writer is employed has recently purchased a machine from Europe for the

study of these conditions and it is hoped that information of considerable value will be obtained.

It may be readily seen that a cylinder iron may, depending on conditions, possess characteristics entirely at variance from those suitable for a flywheel. If the flywheel rim is to be cut with gear teeth its properties may closely approach those of a cylinder in that it should be sound, strong, and possess good wearing qualities. For piston rings we have found that the best results are obtained with an iron high in phosphorus and low in manganese. This iron has the spring-like quality desirable for this part and is not too brittle to stand the test demanded of it, provided the phosphorus does not run higher than about 1.15 per cent. Its hardness depends upon the hardness of the cylinder in which it is to run; that is, it should be a few points higher on the Brinell scale than that of the cylinder, for it must stand more wear. Engine bases and transmission cases should be strong and more ductile than other castings, for usually when made in cast iron they are made as light in section as is allowable, and with the rapid cooling around dry sand cores, internal strains are often set up which may not develop into cracks which are noticeable until subject to the vibration of the motor and the jolts of the car. This may be remedied by the choice of a proper composition of metal not too high in phosphorus and by the use of charcoal iron.

It is almost general practice among automobile foundries to use varying percentages of steel scrap in their mixtures, running from ten to forty per cent. Authorities generally state that the strength increases with the addition of the steel up to the latter amount. This is undoubtedly true if the chemical composition be regulated accordingly, but it has been found in our class of work requiring hot, fluid iron, that the silicon and phosphorus have to be increased to such an extent that the increase in strength is discounted. The increase of these metalloids seems likewise to be deleterious to the machining qualities and softness, and the high amount of steel tends to increase the chilling qualities of the iron to a prohibitive extent when used in connection with the amount of scrap iron necessary for economical production. Turner states that best machining qualities and softness are obtained with a silicon content of about 2.5 per cent, although the maximum tensile and transverse strength are reached between 1.75 and 2

per cent. It has been found that a silicon content of 2.5 per cent with maganese 0.6 to 0.7 per cent and phosphorus about 0.5 per cent gives a very good iron in every respect for lighter castings. For cylinders and pistons the introduction of 10 to 15 per cent steel and lowering the silicon content to 2.15–2.25 per cent increases the strength materially. For flywheels and heavier work which is not machined at a high speed rate of cutting, steel is increased from 20 to 25 per cent and the silicon lowered to between 1.8 and 2 per cent. This gives a very strong iron which is also very suitable for gear teeth.

It seems important then that a grade of metal best adapted to meet the requirements of service be chosen for the type of casting to be made. Of course it is not necessary or practical to run heats of a composition especially designed for each of the numerous castings for motor cars, but it is practical and economical in the long run to divide the different types into classes, three or four in a number, and pour them with the metal best suited to fill the conditions, both from the foundry standpoint and from that of the metallurgist.

As a whole, automobile castings are classed as light work, but, as said before, much of it is intricate work; light and heavy sections adjoining and often with heavy bosses attached. It is not always practical or convenient to use chills, and if these castings could be poured with an iron which would be close-grained and free from draws, sponginess, and segregation under these conditions of design and still meet the requirements of wearing well and having good cutting qualities, a very desirable point would be obtained. Of course there are numerous other important factors to consider which will aid in the production of such an iron, such as the manner of gating the castings. For instance, a piston cast with the bosses solid is much less liable to be spongy if gated about the circumference but between the bosses. Again, a small change in the design will do much toward obtaining the desired result.

It was in order to gain some insight into the vagaries and inconsistencies of cast iron and to correlate, if possible, the chemical composition and rate of cooling with the physical properties such as strength, hardness, resistance to wear and machinability, that a line of experimental work dealing with different brands of

pig iron and varying percentages of steel was undertaken. It seems reasonable to suppose that the crystalline structure of the metals as well as chemical composition is linked with some of these properties. Therefore, in each experimental heat of iron poured, and from each pig iron used in the mixture, microphotographs were made from the test bars and from sections of the pigs.

It has doubtless been the experience of many foundrymen to note that in spite of all consideration and care in mixing and melting of iron, that the metal produced will oftentimes give results absolutely at variance with what might be expected and irons of duplicate analyses may give very different physical results. The question then arises whether or not characteristics peculiar to one brand of pig iron can persist in the final product after mixing with others and going through the cupola. This did not seem probable to the writer, yet results obtained in practice seem to make such a theory tenable, for we found that the addition of 15 per cent of one brand of iron to a mixture increased the strength of the product about 10 per cent, although the analyses of the two products were very close. Likewise the addition of this iron decreased the shrinkage, increased the softness and made the cutting qualities very much better; it was decided then that there was a possibility of developing the quality of the iron through a study of the pig iron.

Through this study and by means of experimenting with various mixtures, it is hoped that a better iron will be produced to meet the requirements of motor car castings. Theoretically, an iron with a pearlitic structure predominating to the greatest possible extent and the excess carbon in the amorphous or temper form would seem to be most desirable. When, however, one considers the large number of variable factors which may influence the structure of the iron, the scope of the problem to be studied can be realized.

We have not as yet done sufficient work to feel warranted in drawing any definite conclusions. While the value of the work undertaken is still speculative, table No. 2 is presented for whatever interest it may have to the foundryman, showing in a condensed form the results obtained from mixing the various irons of table No. 1. Table No. 3 gives some data on the various irons used by the writer for the different classes of automobile work.

For ascertaining the soundness of the metal, four castings of a large single cylinder were poured from each heat. The barrel of the cylinder being light in section, with the outside circled by a heavy flange having a large boss on the cope side, presents excellent conditions for spongy metal. Column under "Remarks" shows whether the castings were sound or spongy.

Table No. 1 is a compilation of different brands of pig iron used by the foundry with which the writer is associated and shows the various chemical compositions. Iron No. 1 is a Northern charcoal brand. Nos. 2 and 5 are Virginia irons; Nos. 3, 4 and 7 are Northern coke irons; No. 6 is a Southern iron; No. 8 a silvery iron; No. 9 is a Cuban iron of special composition, containing, in addition to the elements usually met with, chromium

TABLE No. 1.

No. of Iron.	C. C. per cent.	G. C. per cent.	Total C. per cent.	Mn. per cent.	P. per cent.	S. per cent.	Si. per cent.
1........	0.50	3.06	3.56	0.55	0.114	0.022	1.99
2........	0.53	3.12	3.65	1.15	0.399	0.044	2.17
3........	0.53	2.97	3.50	0.72	0.230	0.018	3.18
4........	0.38	2.84	3.22	0.90	0.531	0.013	3.42
5........	0.63	2.67	3.30	1.12	0.951	0.019	2.05
6........	0.60	2.40	3.00	0.33	1.405	0.047	1.63
7........	0.41	3.01	3.42	0.54	0.736	0.025	2.47
8........	0.00	2.16	2.16	0.87	0.443	0.041	8.88
9*.......	3.63	0.55	4.18	1.18	0.044	0.001	0.49
10........	Trace	3.52	3.52	0.42	0.409	0.027	2.53
11........	0.32	3.07	3.39	0.21	0.404	0.038	1.41

* No. 9 also contains 1.05 per cent nickel and 2.17 per cent chromium.

and nickel and traces of vanadium and titanium. Nos. 10 and 11 are charcoal irons from the New England states.

The amount of space allowable for a paper of this kind precludes the showing of more than a limited number of the microphotographs obtained—something over 200 having been taken. Fig. 1 is a microphotograph of the No. 1 iron, the sample being polished and magnified 50 diameters. The rosette-like structure of the graphite is to be particularly noticed, as this is peculiar to this charcoal brand. A close inspection also reveals the presence of the iron-carbide eutectic, but in relatively small amounts.

Fig. 2 shows the same sample etched and magnified to 1000

diameters. This plate shows in fine detail the structure of the various micrographic constituents, ferrite, pearlite, graphite and eutectic of the iron carbon system sometimes called Ledeburite.

Fig. 3 shows iron No. 2, a Virginia iron, polished and magnified 50 diameters. This sample was taken from a longitudinal section of a sand-cast pig. The short, straight crystals of graphite and the greater predominence of the eutectic constituent is to be noticed in contrast with the charcoal iron of Fig. 1, although both the combined and total carbon contents are very nearly the same for both irons.

Fig. 4 shows the same iron, with the sample etched and magnified 1000 diameters. Here we also have in clear detail the constituents ferrite, pearlite, graphite, and, very clearly outlined in the center of the plate, the eutectic.

Fig. 5 presents a still different structure of graphite; a combination of the short, straight crystals and irregular masses and also what may be called the "pine tree" or dendritic crystallites formed during solidification. It is also to be noted that as the percentage of impurities increases the structure becomes more complex. This sample is taken from a cross-section of a machine-cast pig and shows the effects of the rapid cooling of iron cast in this way.

Fig. 6 is the same sample etched and magnified 100 diameters. Here the dendritic structure is shown in a very pronounced form. In the center of the plate some dendritic crystals are shown partially metamorphosed.

Fig. 7 shows a portion of the dendrite of Fig. 6 magnified to 1000 diameters: Some of the original ribs of the eutectic are shown and also some of the pseudomorphic graphite derived from the decomposition of the cementite in the same.

Fig. 8 shows a sample of iron No. 4 polished and magnified to 100 diameters, taken from a machine-cast pig. This iron is made from the same ores as iron No. 3, although the furnaces are not located in the same cities. The analyses are not widely different, yet the structure is, the graphite being in more coarse and irregular areas.

Fig. 9 is a sample of iron No. 5, magnified to 100 diameters; a sand-cast pig of a Virginia brand. While the silicon content is much less than in the preceding two irons and the total carbon

Table No. 2.

Heat Number.	Iron No. 1.	Iron No. 2.	Iron No. 3.	Iron No. 4.	Iron No. 5.	Iron No. 6.	Iron No. 7.	Iron No. 8.	Iron No. 9.	Hard Scrap.	Soft Scrap.	Steel Scrap.	Ferro Manganese, lbs.	Combined Carbon.	Graphitic Carbon.	Manganese.	Phosphorus.	Sulphur.	Silicon.	Nickel.	Chromium.	Shrinkage.	Depth of Chill, ins.	Brinell Hardness.	Tensile Strength, lbs. per sq. in.	Transverse Strength ½-in. bar.	Remarks.
1	33	..	..	..	56	..	..	..	..	..	..	10	..	0.58	2.91	0.61	0.60	0.093	1.83	....	....	0.159 0.163	0.18 0.23	217	29,800	450	Metal in boss of castings spongy. Machine well.
2	23	..	..	..	26	..	..	16	..	..	..	33	3	0.59	2.37	0.80	0.459	0.105	1.90	....	....	0.169 0.164	0.26 0.23	228	32,766	485	Grain of metal very close and fine. Castings all sound.
3	33	..	..	53	..	..	..	5	..	..	..	10	1	0.61	2.88	0.53	0.593	0.096	1.81	....	....	0.164 0.155	0.20 0.19	212	31,583	445	Castings about same as No. 1.
4	33	..	..	56	..	..	..	..	..	..	..	10	2	0.64	2.16	0.47	0.364	0.050	1.94	....	....	......	......	....	22,708	....	Castings badly spongy.
5	21	..	..	25	..	..	..	20	..	..	..	33	5	0.62	2.44	0.85	0.504	0.112	1.89	....	....	0.173 0.166	0.50 0.50	235	30,600	460	Grain of metal close. All castings sound.
6	21	..	..	26	..	..	..	18	..	..	..	33	3	0.71	2.00	0.44	0.333	0.115	1.86	....	....	......	......	....	36,500	....	Grain not so close as No. 5, but all castings sound. One cylinder misrun.
7	..	..	50	..	..	..	..	16	..	..	..	33	2	0.58	2.44	0.69	0.551	0.100	2.45	....	....	0.168 0.162	0.18 0.16	235	32,400	455	Grain fairly close on 3 castings; 1 spongy.
8	..	..	25	..	..	..	..	18	..	23	..	33	2	0.54	2.41	0.54	0.483	0.121	2.49	....	....	0.169 0.164	0.24 0.19	235	32,400	480	Grain close. All castings sound, but 2 cold shut.
9	..	..	25	..	..	..	..	18	..	23	..	33	3	0.64	1.98	0.54	0.515	0.140	2.00	....	....	......	......	....	35,650	....	One casting sound; 2 with small spongy spots; 1 badly spongy
10	25	..	..	..	..	..	..	18	..	..	23	33	3	0.55	2.32	0.53	0.462	0.110	2.48	....	....	0.169 0.164	0.22 0.22	235	......	450	One casting sound; 2 slightly spongy; 1 badly spongy.
11	25	..	..	..	..	..	..	20	..	..	21	33	3	0.62	2.25	0.62	0.356	0.105	2.78	....	....	......	......	....	37,550	....	Grain close and fine. All castings sound.
12	..	..	..	..	28	..	..	16	..	..	21	33	1	0.60	2.42	0.47	0.63	0.115	2.27	....	....	0.168 0.163	0.28 0.30	235	32,733	445	One casting good; 3 spongy.
13	..	25	..	..	..	..	..	16	..	25	..	33	..	0.60	2.22	0.46	0.535	0.111	2.53	....	....	0.168 0.171	0.28 0.29	235	37,760	480	These castings had bad spongy areas; 1 badly spongy.
14	43	..	..	..	..	..	..	23	..	..	..	33	3	0.57	2.47	0.55	0.293	0.105	2.39	....	....	0.165 0.162	0.18 0.10	217	32,000	500	Necessary to enlarge gates to run well; 3 castings misrun. Heat rerun; all castings sound; grain close and fine.
15	..	..	..	..	..	58	..	8	..	..	..	33	..	1.40	2.44	0.23	0.962	0.131	1.99	....	....	0.191 0.180	All chill	255	32,130	385	Castings all good. Grain very light gray.
16	..	..	46	..	..	..	..	3	13	..	36	..	2	0.55	2.98	0.44	0.452	0.087	2.18	0.20	0.46	0.195 0.157	0.09 0.06	205	24,100	455	Grain open. All castings with large spongy spots.
17	30	..	..	..	..	..	..	15	..	..	25	30	..	0.49	2.54	0.62	0.319	0.093	2.12	....	....	0.166 0.166	....	215	......	450	All castings good; grain close; machine well.
18	30	..	..	..	..	..	..	17	..	..	22	30	3	0.55	2.40	0.69	0.34	0.089	2.29	....	....	0.166 0.160	0.30 0.08	210	......	450	Grain close; castings good. Machined fair; some hard spots; tendency to chill.
19	30	..	..	..	..	..	..	18	..	..	21	30	3	0.43	2.52	0.63	0.312	0.081	2.23	....	....	0.169 0.160	0.36 0.26	200	......	480	Grain good; all castings good. Machine poorly; hard spots; tendency to chill.
20	30	..	..	..	..	..	..	30	..	..	..	40	3	0.57	2.44	0.48	0.581	0.100	2.76	....	....	0.154 0.160	0.18 0.26	212	......	425	Grain good, but metal tough and machines poorly.
21	23	..	..	..	..	..	..	36	..	..	..	40	3	0.46	2.41	0.48	0.651	0.113	2.87	....	....	0.154 0.152	0.22 0.13	207	34,120	445	Grain good; too hard and tough for machining well.

about the same, yet the structure of the graphite is in very large crystals.

Fig. 10 shows the same iron etched and magnified to 100 diameters. Here we have a star-like formation of the graphite with pearlite surrounding the same and "Steadite," the phosphide eutectic, in relief.

Fig. 11 is a sample of iron No. 6 polished and magnified 50 times. The phosphorus content being high and the combined carbon also rather high, we have the "Steadite" constituent to a marked extent.

Fig. 12 shows the same sample magnified to 1000 diameters and etched. Here the detail is shown: graphite, ferrite, pearlite, and Steadite.

Fig. 13; this is a sample of iron No. 7, polished and magnified to 50 diameters. The same brand as iron No. 3, but sand cast and taken from the edge of the pig. The slower cooling is evidenced in the coarse graphite crystals.

Fig. 14 is from the same pig as Fig. 13, but the photomicrograph was taken from a sample at the center of the pig. Here the graphite is very abundant and coarse, and but very little Steadite can be seen in relief.

Fig. 15 shows the same sample as Fig. 14, but etched and magnified to 500 diameters. Here is shown in the center of the photomicrograph a partially decomposed area of Steadite and bordering it finely divided graphite, a decomposed product from cementite.

Fig. 16 shows sample of iron No. 8, a high silicon or silvery iron polished and etched to 50 diameters. Graphite is very abundant, with no evidences of the eutectic constituents. This plate is taken from the edge of a sand-cast pig.

Fig. 17 shows the same iron etched and magnified to 1000 diameters. Here the boundary lines of the crystals of ferrite can be distinctly seen; the center of the ferrite shows a mass of the silico-carbide constituent.

Fig. 18 shows the same iron etched and magnified to 1000 diameters; detail of silico-carbide area very clearly shown.

Fig. 19 is taken from a sample of iron No. 10. This plate shows a section taken from the outside of a pig. This is a charcoal brand of iron, but from a section of the country very remote

from iron No. 1. By referring to Fig. 1 it will be noticed that there is a similarity of structure between the two irons, although the percentage of metalloid in No. 10 is larger than in No. 1. This photomicrograph is at a magnification of 50 diameters and is simply polished without etching.

Fig. 20 is a sample from iron No. 11; the same brand as iron No. 10, although the percentage of silicon is over 1 per cent lower. This sample is at the same magnification as Fig. 19 and likewise taken from the edge of the pig.

Figs. 21, 22, 23 and 24 show sections of ½-inch-square test bars taken from the four irons used in the company by whom

TABLE No. 3.

Class of Iron.	Piston Ring.	Cylinder.	Flywheel.	Soft.
Combined carbon	0.60–0.70	0.50 –0.60	0.60 –0.70	0.30 –0.40
Graphitic carbon	2.40–2.75	2.25 –2.80	2.25 –2.60	2.75 –3.25
Manganese	0.25–0.35	0.65 –0.75	0.60 –0.75	0.60 –0.75
Phosphorus	1.00–1.15	0.40 –0.45	0.40 –0.45	0.45 –0.55
Sulphur	0.08–0.10	0.075–0.095	0.075–0.095	0.075–0.095
Silicon	1.80–2.00	2.10 –2.25	1.80 –2.10	2.40 –2.60
Tensile strength	29,190	35,780	37,400	27,020
Transverse strength	2,680	3,710	3,500	2,720
Shrinkage	150–160	155–160	160–165	148–154
Depth of chill	10–20	10–20	0.15 –0.25	0.00 –0.10
Brinell hardness	228–235	207–212	212–217	174–187
Per cent steel in mixture	0–10	10–15	20	None
Per cent scrap in mixture	50–60	50–55	45–50	50–60

the writer is employed. They are what are called soft iron, piston ring iron, flywheel iron and cylinder iron, respectively. The photomicrographs are all at 100 diameters magnification, polished and etched with picric acid. The bars from which these samples are taken are all gated and poured under the same conditions as nearly as possible. Table No. 3 gives some statistics regarding these irons.

Fig. 25 is taken from a section of a test bar from heat No. 14. The pearlitic structure predominates here. This is a very good iron, close grain, tough, and all castings poured from it were sound.

Fig. 26 is taken from a section of a test bar from heat No. 15. It shows how, in a high phosphorus iron, the phosphide eutectic has a tendency to segregate.

In conclusion it may be said that during the coming year we hope to do more work along this line and that more definite data will be secured, which will be of practical value.

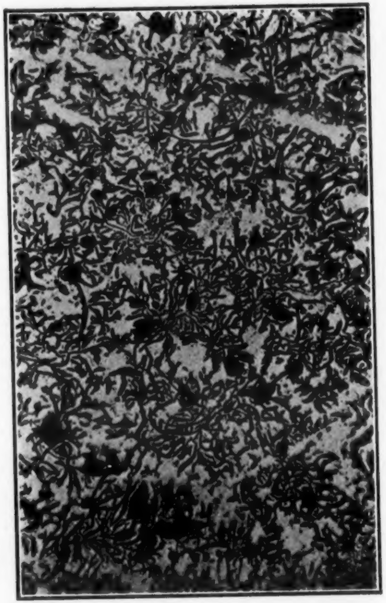


FIG. 1.—IRON NO. 1. × 50. POLISHED.

FIG. 2.—IRON NO. 1. × 1000. ETCHED.

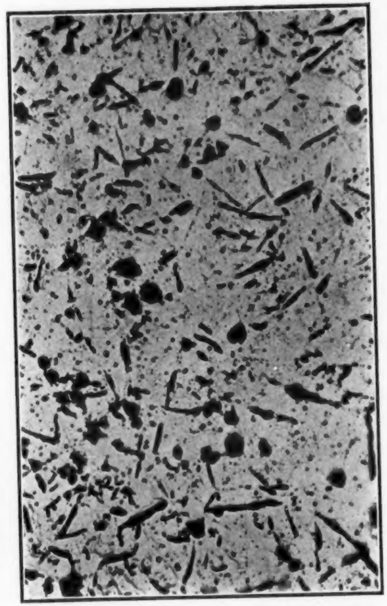


FIG. 3.—IRON NO. 2. × 50. POLISHED.

FIG. 4.—IRON NO. 2. × 1000. ETCHED.

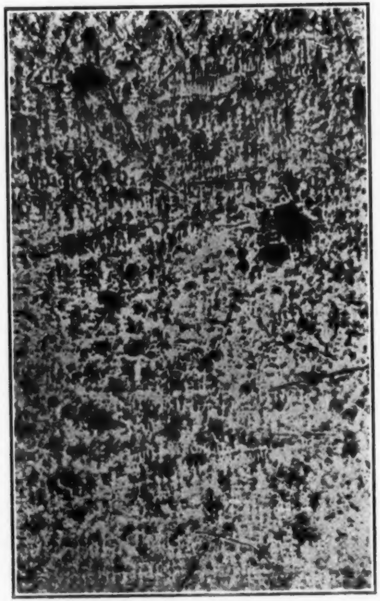


FIG. 5.—IRON NO. 3. × 50. POLISHED.

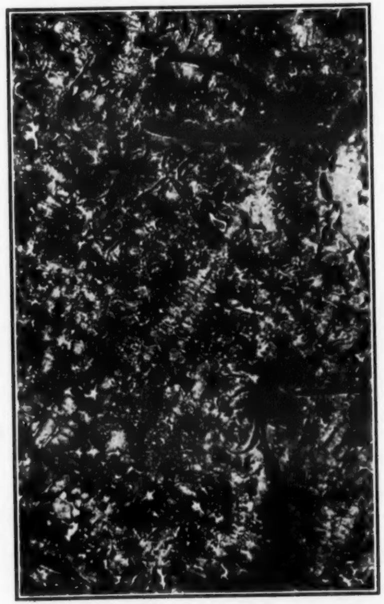


FIG. 6.—IRON NO. 3. × 100. ETCHED.

FIG. 7.—IRON NO. 3. $\times$ 1000. ETCHED.

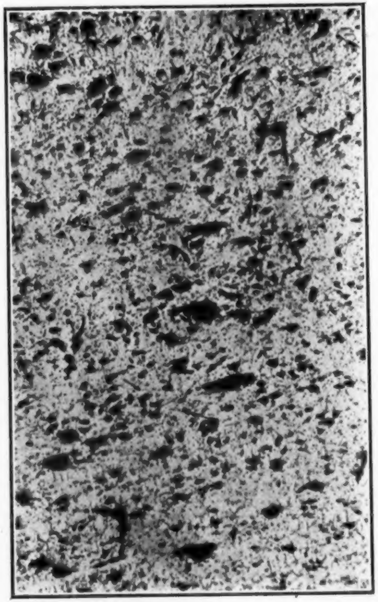


FIG. 8.—IRON NO. 4. $\times$ 50. POLISHED.

FIG. 9.—IRON NO. 5. $\times$ 100. POLISHED.

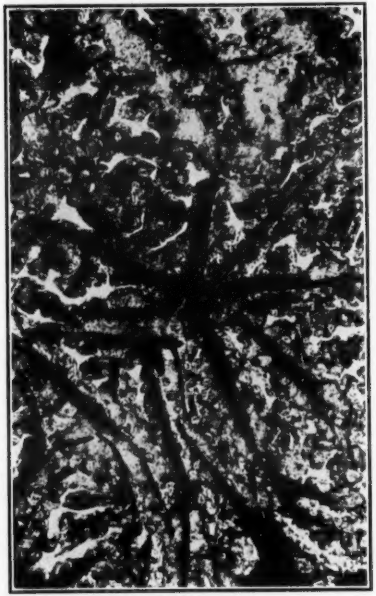


FIG. 10.—IRON NO. 5. × 100. ETCHED.

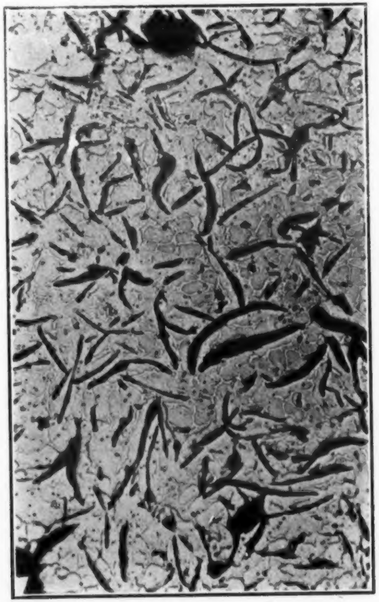


FIG. 11.—IRON NO. 6. × 50. POLISHED.

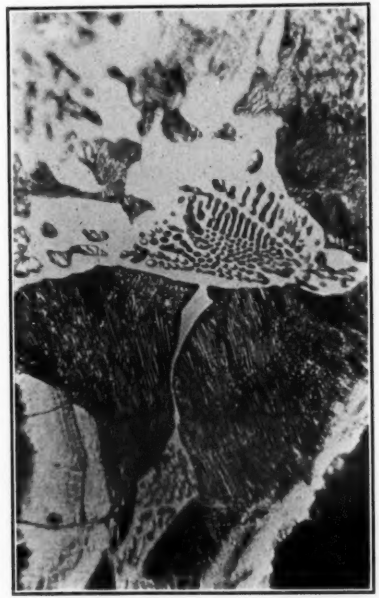


FIG. 12.—IRON NO. 6. × 1000. ETCHED.

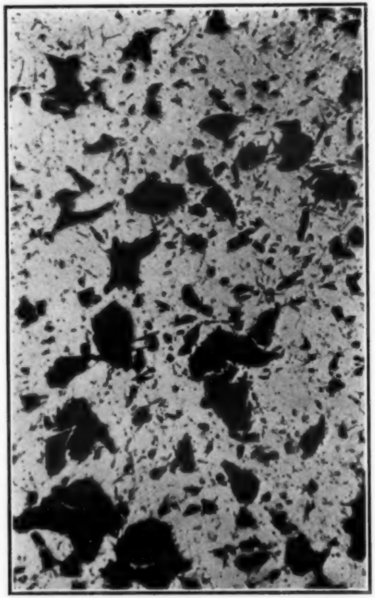


FIG. 13.—IRON NO. 7. $\times$ 50. POLISHED.

FIG. 14.—IRON NO. 7. $\times$ 50. POLISHED.

FIG. 15.—IRON NO. 7. $\times$ 500. ETCHED.

FIG. 16.—IRON NO. 8. $\times$ 50. POLISHED.

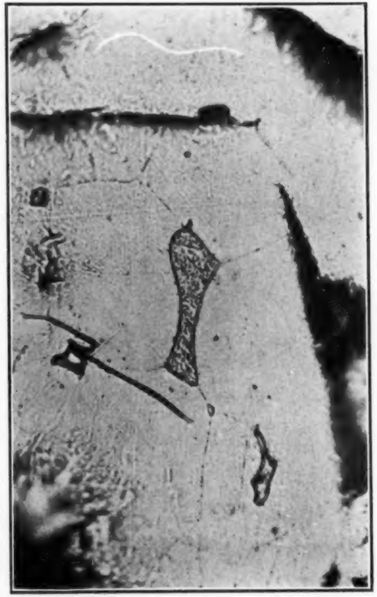


FIG. 17.—IRON NO. 8. $\times$ 1000. ETCHED.

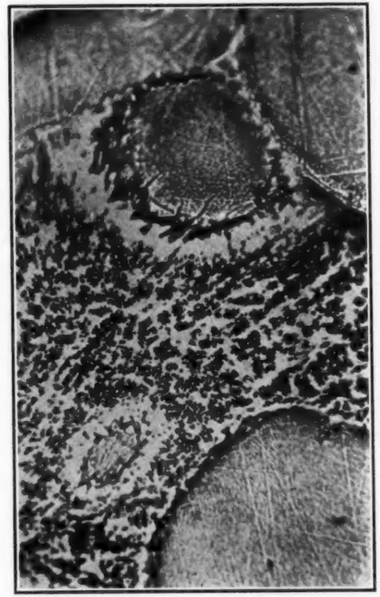


FIG. 18.—IRON NO. 8. $\times$ 1000. ETCHED.

FIG. 19.—IRON NO. 10. × 50. POLISHED.

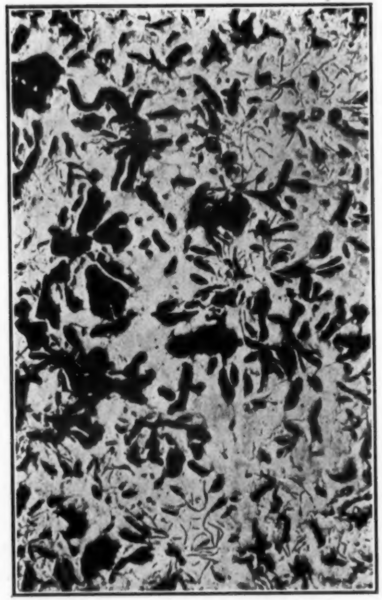


FIG. 20.—IRON NO. 10. × 50. POLISHED.

FIG. 21.—SOFT IRON. × 100. ETCHED.

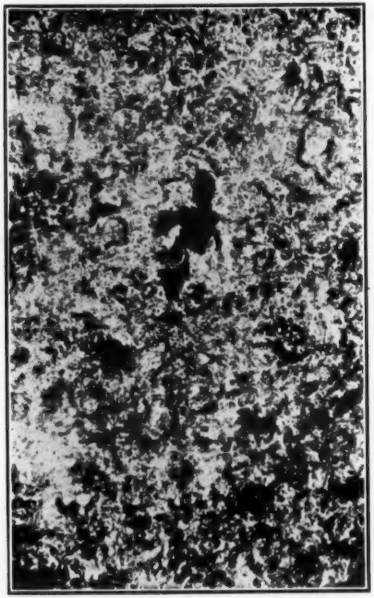


FIG. 22.—PISTON RING IRON. $\times 100$. ETCHED.

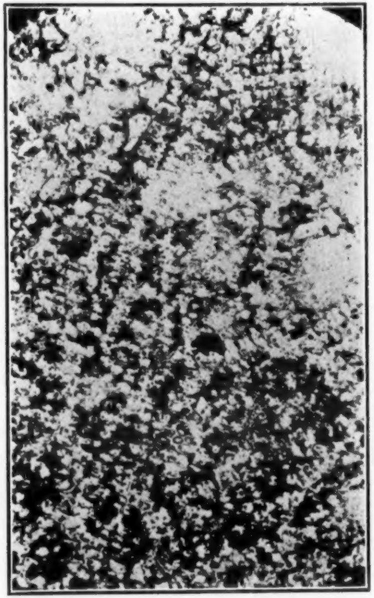


FIG. 23.—FLYWHEEL IRON. $\times 100$. ETCHED.

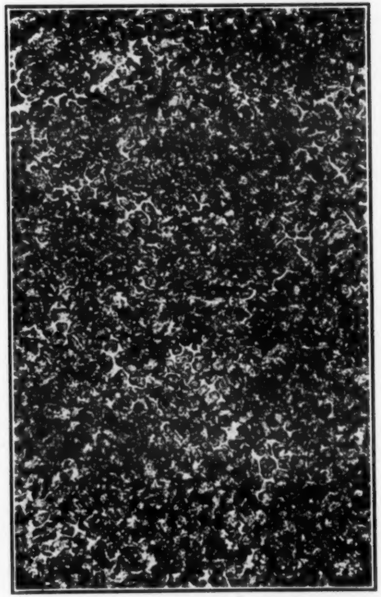


FIG. 24.—CYLINDER IRON. $\times 100$. ETCHED.

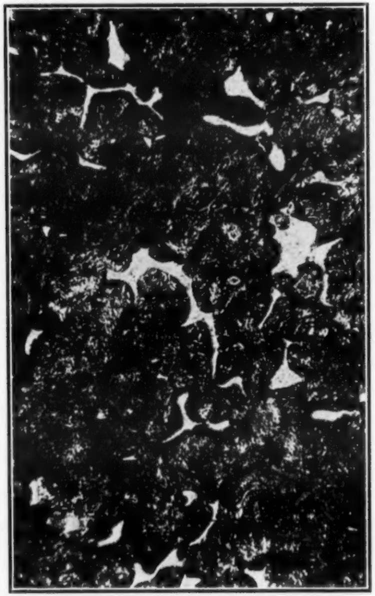


FIG. 25.—HEAT NO. 14. × 500. ETCHED.

FIG. 26.—HEAT NO. 15. × 500. ETCHED.

ELECTRIC STEEL CASTINGS.

By F. T. Snyder, Chicago, Ill.

The following is a short statement of the present situation regarding the electric melting of steel for small castings. It refers entirely to the practice of melting cold steel scrap with electricity, as developed in commercial use in American jobbing foundries. Such foundries usually pour less than ten tons of steel per day. The electric refining of steel previously converted in fuel furnaces for structural and tool purposes is not considered here.

Electric steel castings have been on the American market from a number of jobbing foundries for several years, and this use of electric furnaces for melting steel for small castings is rapidly spreading. The growth is due principally to the fact that steel in small quantities can, under usual conditions, be poured at a decidedly lower total cost from an electric furnace than from fuel-heated furnaces.

A secondary reason for the growth of the practice is that the present quality of electric steel castings is somewhat better than the quality poured from fuel-melted steel. This improvement in quality does not as yet command an increased price, but operates to attract business to the foundries using electric furnaces. In the Middle West the electric steel foundries ran to capacity through the months of this last spring when many crucible and converter plants were running on part time. It is practical with electric melting at a small increase of the usual melting cost to produce castings decidedly better in quality than those now on the market as soon as the demand for such extra quality exists.

The improvement in quality of electric castings is primarily in the increased resistance to suddenly applied loads, making it permissible to use castings for parts subject to shock, such as auto truck brackets, where converter and crucible castings have proven unreliable. The quality increase in this direction is large,

electric castings standing two and three times the number of drop hammer blows required to break fuel-melted steel of the same carbon contents in the same pattern. The tensile strength of electric steel is 5,000 to 10,000 pounds higher than the fuel-melted steels for the same carbon. This is in part due to the higher specific gravity of the electric steel which in turn comes from the smaller volume of microscopic blow-holes.

The cost of electric melting is lower than crucible melting principally because the electricity costs less than the crucibles, so that the competitive cost of fuel is immaterial. The cost of electric melting is lower than side blow converter practice because the steel scrap melted in the electric furnace costs so much less than the high silicon pig iron required for the converter that the difference more than pays for the electricity. The labor and refractory costs for both crucible furnace and converter are considerably higher than with an efficient electric furnace. The tonnage of the usual small casting steel foundry is so small that a small open hearth furnace can operate only part of the day with resulting labor and refractory costs that are higher than for the same tonnage from a well designed electric furnace.

The following table gives the general costs of electric steel in the Middle West for the usual range of tonnages for twenty-four and twelve hour operations. Owing to the general practice of charging for electric power on a system of a primary demand charge per kilowatt plus a secondary consumption charge per kilowatt hour, the cost of electricity per unit is much less for twenty-four hour operation than for twelve hour operation. A furnace loses heat during the night with twelve hour operation, which has to be put in again when the furnace starts up in the morning. These two items make the cost of twenty-four hour continuous electric melting decidedly lower than for twelve hour operation. This table refers to the operation of a specific type of furnace of high average efficiency.

This cost per ton table is based on the following charges:

Labor—

Melter	\$5.00 per day
Assistant melter	4.00 " "
Helper	3.00 " "
Laborer	2.00 " "

Electricity—Off Peak—	
Primary charge—	Basis
First 100 K. W	$15.00 per year
Rest	9.00 " "
Secondary charge	7/10c. per K.W.H.
Stock—	
Punchings	$11.00 per 2,000 lbs.
Heads and gates	8.00 " " "
Pig iron	12.00 " " "
Alloys—	
Ferrosilicon	$40.00
Ferromanganese	50.00

Interest, depreciation, supervision and overhead are not included as they are about the same as for fuel-heated furnaces and differ widely from one foundry to another.

ELECTRIC STEEL MELTING.

Middle West Conditions. Public Service Electricity.

Costs per ton melted.

Hours run per day	12	12	12	24	24	24
Tons melted per day	4	8	12	5	10	20
Labor	$2.50	$1.25	$0.84	$2.80	$1.40	$0.70
Electricity	10.20	8.01	7.58	7.20	6.39	5.32
Supplies	1.94	1.17	.95	2.20	1.41	.88
Conversion cost	$14.64	$10.43	$9.37	$12.20	$9.10	$6.90
Scrap	10.90	10.90	10.90	10.90	10.90	10.90
Ferroalloys	.60	.60	.60	.50	.50	.50
Melted metal cost	$26.14	$21.93	$20.87	$23.60	$20.50	$18.30

The use of electric steel reacts to some extent upon the foundry practice. The electric steel can readily be made very hot, so that extremely thin sections can be poured if desired. Anything that can be poured in gray iron will run with this hot steel. Owing to the neutral chemical condition of properly made electric steel, it is quieter and less precautions have to be taken

against blow-holes from metal causes. The shrinkage is greater than with crucible or converter steel. More allowance has to be made on some patterns for machining. Owing to fluidity gates and heads can be made somewhat smaller.

Electric melting supplies a ready way of making alloy steels. The alloy can be added in the furnace. The electrical action causes sufficient movement of the steel to thoroughly mix the alloy. It has been found practical to remelt the heads and gates from alloy castings with practically no loss of alloy contents. With manganese steel this represents a substantial saving in cost of operation.

It is to be noted that the development in this electric steel melting for small foundries is in melting cold steel scrap rather than in using melted iron from a cupola. The principal reason for this is a matter of cost. It is usually cheaper to melt cold steel scrap than to use melted pig iron. Melted cast iron contains 265 kilowatt hours of electric heat per ton. Against this apparent saving there are certain items of additional expense, which considerably more than offset the saving. Pig iron costs more than the steel scrap that an electric furnace can use. There is a higher metal loss. The pig iron that is commercially available is relatively high in phosphorus and sulphur, and the time required for refining out these impurities adds to the cost. To reduce the carbon within a reasonable time from pig iron values to the usual limits for steel castings requires the addition of iron oxide, usually iron ore. This leaves an oxidizing slag and requires a more skilled melter to pour quiet steel from melted cast iron, than from cold melted steel scrap. If this extra time and skill is not given when using melted cast iron, the loss of casting will be high. When melting cold steel scrap the loss of casting can be made lower than with any form of fuel melting.

The secondary reason for not using melted cast iron for electric steel which is not important at present, but promises to be commercially important when the demand arises for better grade castings, is that the less hot nitrogen that comes in contact with hot steel, the better the quality of the steel appears to be. The cupola blast is four-fifths nitrogen.

EXTRA COST.

Melted Cast Iron—Cold Steel Scrap.

5 tons per 12 hours.

Cost of cupola melting		$0.80	
Extra electric furnace time—			
Labor	$0.90		
Electricity	2.55		
Supplies	1.00		
	——	4.45	
Stock—			
Pig iron, 2,150 lbs. at $13	$13.97		
Steel scrap, 2,050 lbs. at $11	11.28		
	——	2.69	
		——	$7.94
Saving in electric power with melted cast iron, 265 kilowatt hours at 1¼ cents			3.32
			——
Extra cost, melted cast iron over cold steel scrap			$4.62

REPORT OF THE COMMITTEE ON INDUSTRIAL EDUCATION.

By P. Kreuzpointner, Chairman, Altoona, Pa.

Introductory.

Since the last annual meeting your committee on industrial education has been active aiding in the establishment of industrial schools, and to encourage the authorities to increased efforts where such schools are already in operation. The opportunities for being useful in this direction are increasing because of the slowly growing conviction that industrial education in some form will have to be extended impartially to all industrial workers alike, male and female, skilled, semi-skilled and unskilled. Local conditions will then determine the nature of the special schools needed for particular trades or occupations in a given locality. These special schools should be built upon an efficient system of general or preparatory industrial schools, which in turn rest upon the public school system. Out of the special vocational schools there should grow schools for specially highly skilled mechanics and foremen for particular trades.

Thus, upon the one hand the existing and already highly organized public school system could and should be made to contribute to the industrial and civic needs of our manufacturing and agricultural population; while upon the other hand there would be no sharply outlined division between public school education, industrial and agricultural education of a general nature, and specific vocational training for particular trades and occupations.

In such a system of schools there would be a grading of scope and efficiency, making provision for the talented workers rising to the top; thus doing justice and giving opportunity to all. while amply providing for the educational needs of the industries and the community.

In any single industry as well as in our whole industrial

fabric, the character of the workingmen and the average quality of product is, in the last analysis, determined by the average degree of intelligence and sense of responsibility of the employees of all grades. No amount of superlative refinement of method or knowledge of any single department will raise the average quality of product if the average degree of intelligence of the force is low. However slight the contribution may be to the success of a concern by the individual unskilled worker, collectively their work contributes to the success of an undertaking, and therefore industrial education should mean more than the training of a few highly skilled mechanics. In the end the mass always rules, no matter what form of government there is, or what the state of the industry may be, or irrespective of how highly educated those on top of society may be. History tells us that if the degree of intelligence of the mass of citizens is low the results of their rule will be correspondingly low.

Trend of Industrial Education Toward Shop Schools.

Your committee is gratified to report an increasing sentiment among the authorities in charge of technical and industrial schools in favor of adding foundries to their school equipment.

While, from the standpoint of the practical needs of the foundry industry, these school foundries are of little immediate help, nevertheless, the movement is gratifying and helpful as a recognition of the value of the industry. Your chairman, during his frequent visits to schools, encourages the school authorities to give the foundry a trial. However, whatever the willingness of the school authorities may be, there is no prospect at present for the establishment of preparatory schools for the foundry.

There is a growing disposition by municipalities to establish continuation schools, part-time schools, technical high schools or industrial departments in academic high schools, according to the needs of the locality. As a counterpart to this disposition for general preparatory industrial schools by municipalities there is a growing tendency on the part of railway companies and manufacturers to establish shop schools, that is apprentice schools of their own. There are at present seventy-one of such schools in successful operation.

This tendency on the part of manufacturers to have schools of their own, together with that other tendency of individual concerns or groups of related industries in sending their employees to specifically organized continuation schools, promises to offer a natural solution for the difficult problem of specific trade training, provided the public educational system furnished a sufficiently effective preparatory industrial education in high grade continuation or similar kinds of schools, so as to give the employer as well as the community the full benefit of the shop school. While it is true that shop schools and continuation schools have proven their value for the outlay of time and money through increased efficiency, the community is also indirectly the gainer by whatever raised the standard of efficiency of the industrial workers, and therefore owes it to itself, in its own interest, to co-operate with the employer in furnishing him the best possible prepared material for his shop and continuation schools. Where an industry, like a foundry, is not large enough for a shop school of its own, several industries may join in the organization of a school, or, where this is not feasible, have arrangements made with the school authorities for a continuation school on the plan of the continuation school for the metal trades in Cincinnati. There is no reason why an industry, or a group of industries, should not train their own employees, even the semi-skilled, along their specific requirements of the trade. The shop can do that very much better than the school.

Leaving out of consideration a few endowed and really good trade schools the number of pupils of which form only an insignificant percentage of the skilled men needed in the foundry or any other industry and few of whom are eventually found in the shops, the training for a trade in a specific trade school is too expensive for the average community to become a relief for the industries to any extent.

At present the cost per pupil in a specific trade school runs from $150 to $300, and though this cost may be reduced somewhat in the course of time, yet, with the expenses in all other departments of education rising, there is little prospect of trade schools furnishing any appreciable help to the industries in the near future. As a rule, the boy who is willing or able to stay in a trade school three or four years without pay aspires higher than to remain a piece worker for any length of time.

If the foundry industry, or any other industry, objects to shop schools for the reason that on account of labor shifting they would train help for their competitors, this objection could be minimized, if not annulled, in two ways. There is a disposition in many States to pass laws encouraging or compelling communities to establish industrial schools, and there is even a growing sentiment to make attendance at such schools compulsory between the ages of fourteen and sixteen. Then again there is a growing disposition and effort on the part of the more farseeing and progressive educators to co-operate with each other in different parts of the country, in order to bring order and uniformity of effort out of the great diversity of opinion and experimenting in industrial education in hundreds of places. Now, then, if the industries and the workingmen throw their weight of influence in the balance to have as many States as possible pass laws favoring or compelling the establishment of industrial schools; if at the same time they encourage and co-operate with the progressive educators to shape these schools so that the industries and agriculture get what they need most; if they compel the reluctant and standpat educators to follow the lead of the progressive ones, then industrial education will shortly be so widespread and at the same time so tolerably uniform in its essentials, that the industry which loses a portion of its shop trained men to a competitor will have fewer direct losses because of State laws, the co-operation of the educators and the growing number of shop schools and continuation and part-time schools supported by groups of industries. These will equalize the discrepancies in industrial education between cities and different parts of the country.

While we cannot and should not introduce European educational methods into our American schools, our industrial people and educators could learn much from our European competitors regarding the value of co-operation and State laws making industrial and agricultural education effective in the interest of the State, the community, the industry, agriculture and of the school.

And the American Foundrymen's Association can help the good work along for its own benefit.

The universities and colleges are united in prescribing to the high school what kind of preparation they are to give to the students entering college and the colleges are very energetic in seeing

to it that they get from the high schools what they want. There is no reason why the industries and the workingmen should not likewise get together and, instead of denouncing the schools and school people as backward and incompetent, which is not always true and only creates a feeling of distrust and resentment, prescribe to the schools what preparation they want for the young people going into the industries; and insist upon getting it just as the colleges do.

This would be practical and businesslike without encroaching upon the professional expertness and prerogatives of the school men to whom would be left the arrangement of the details of carrying out the plan. Such a co-operative advisory position, accorded to the industries, would likewise prevent the domination of the industrial school by the academic teachers to any great extent, while at the same time securing for the industrial school the help of the academic teacher whose experience is valuable. Only about ten of every hundred children entering the primary grade pass through the high school; why should not the State and municipality spend as much for the ninety who do not go through the high school as for the other ten? Will the better education of the ten counteract the disadvantages arising to the community and to the industries from the intellectual and educational deficiencies of the ninety? Will it be better for society to neglect the ninety?

A Proposed Separate System of Industrial Schools.

There is a movement on foot now to create a system of industrial (vocational) schools, separate and distinct from the existing organized system of public schools, leaving the public school to follow in the wake of the industrial school if it will, but making no particular attempt to benefit from the traditional educational system. The reason for this attitude of the advocates of the movement is the almost universal unsympathetic attitude of the school people towards industrial education, and the fear that as manual training has been emasculated and has been made part of the academic school system, to the disadvantage of the industries, so likewise would industrial courses, if connected with the public school system and dominated over by the academic

teacher, be soon emasculated and become part of the academic school system and be dominated over by the academic teacher, to the disadvantage of the industries.

While your committee is well aware of the unsympathetic attitude of the school people towards industrial education, it thought it to be in the interest of the industries, and of the foundrymen in particular, not to join this movement for a separate system of industrial education—although your committee has always been in favor of separate industrial schools. These, however, should be co-ordinated to the existing public school system, benefiting from its organization and co-operating with it where such co-operation is of advantage to the industrial school, but not to subordinate the industrial school to the public school in the manner manual training has been subordinated to the elementary school.

Just as no judicious manufacturer would discard valuable machinery when the readjustment and strengthening of some parts would save the installing of new machinery, so your committee thought it for the best to devote its energies to helping in the readjustment of the already existing highly organized system of public schools in order not to lose its valuable help in preparing, through differentiated courses in the elementary schools, those who will enter the industrial schools when leaving school.

Making due allowance for over-conservatism and of the absurd claim of many, especially high school teachers, that industrial education has no cultural value, your committee believes that much of the unsympathetic attitude of the school people towards industrial education has been fostered by the manner with which the subject of industrial education has been forced upon them and the blaming of the teachers for conditions which were caused by too much politics, social and business influences entering the school. for the presence of which the teachers were the least responsible.

Your committee, weighing these circumstances and believing that the unsympathetic attitude referred to is steadily diminishing as the teachers become better acquainted with the industrial, therefore thought it best not to deprive industrial education of the valuable co-operation of the existing organization. This mutual misunderstanding between the school people and the

industrial people is largely due to the haste and necessity of late years to give to the industries the badly needed skilled help, and under the spell of the prevailing optimism it was believed we could make out of our schools a "Jack of all education" the same as until quite recently it was thought every boy was fit for a "Jack of all trades." We are finding out the need of separate industrial schools but this should not lead us to the wasteful method of creating an independent system of industrial education with a distinct organization. By pursuing an attitude as outlined above, your committee believes itself to be in a better position to serve the foundry industry by gaining the good will of the educators, as is attested by the following excerpts of letters received by your chairman:

"You and your Association are doing a splendid work. Such a course of study as you suggest, if enforced by requirement and recognized by industry, would, in a generation, relieve the country of half of its crime."

"Our supervisors enjoyed your talk very much and we all agree with your main proposition."

"I have examined this material with greatest interest and profit and thank you for making available so many clarifying and illuminating thoughts and facts on this most important subject."

"You are a mine of information and your papers contain just what I wanted."

"It is particularly gratifying to have this letter from you, since you have given a great deal of thought to the subject, and because of your influential position as Chairman of the Committee on Industrial Education of the American Foundrymen's Association."

"Your suggestions will be given careful study and possibly some of your recommendations may be realized in this city. At least I will make a strenuous effort."

"The work of industrial education is rapidly progressing in our Southland and I believe that the articles you gave me have played no little part in this development."

"All your writing is strong and convincing. You must not mind calling you a 'crank.' You are only a little ahead of your time and have to take the consequences."

"The receipt of your article on 'Feudalism in Education' is

acknowledged with appreciation, particularly of the argument for continuity in organization"

"We are experimenting here and I wish you point out what to you appears more advisable."

"We are ready to return the valuable material which you so kindly loaned us. Our history department has oftentimes expressed great satisfaction at the valuable services which you have rendered them, and I desire personally to add my sincere thanks."

It will be seen from the above that your chairman is in a fair position to be helpful to both sides without sacrificing the educational interests of the industries.

During the past year your chairman has had the pleasure to address the Chamber of Commerce at Erie, Pa.; the Ohio Association of Manual Training Teachers at Columbus, Ohio, and to deliver a lecture on "The German Guilds of the Middle Ages" at Teachers' College, Columbia University. Your chairman also received an invitation from the Pennsylvania State College to assist, as special instructor, at its summer school for the training of teachers for industrial schools, and in the educational interest of your association attended the second convention on Vocational Guidance at New York, the Pennsylvania State Education Association convention at Harrisburg, the convention of the Department of Superintendents of the National Education Association at Philadelphia, the convention of the American Society for the Promotion of Industrial Education at Philadelphia, the convention of the Eastern Art and Manual Training Association at New York, the commencement exercises of the School of Industrial Art at Trenton and the commencement exercises at the Williamson Trade School in Delaware County, Pa.

While on a visiting tour to the industrial schools of Philadelphia, Trenton, Newark, New York, Boston, Lawrence, Worcester and Springfield, your chairman was particularly gratified to find the foundry school at Wentworth Institute in Boston well patronized and in a very promising condition to be of service to the foundry industry.

While from a school of that kind no help may be expected for the training of journeymen molders the school being of too high grade to be of service to the foundry industry in this direction, nevertheless, the opportunity offered to receive special training

in the art of founding along modern, scientific efficiency lines is a progressive movement of great value and significance to the foundry industry. But at the same time a high grade school of this kind emphasizes the great gap to be filled in our whole modern industrial and social fabric; not to begin our education at the top, but to begin to prepare the millions who eventually will follow industrial pursuits, by a suitable differentiation in the elementary schools for the continuation or similar industrial schools, which in turn offer a suitable preparation for trade or shop schools, or high grade schools like the Wentworth Institute, Pratt Institute, etc.

Starting out, as we do in this country, with the establishment of a new system of education which. from its nature and the uses it is to be put to, is to serve as an agency in fitting a large percentage of the population not only for their occupations but for a new social status and severe economic conditions of life, the following principles suggest themselves:

1. Not to spend too much energy and the taxpayers' money for the exclusive training and development of faculties and popular inclinations which, like the inventive spirit and love for mechanical exercise, have already become a second nature with the people at large. While this is an easier process, it tends to neglect the development of other valuables faculties which are necessary to produce harmony of thinking and develop common sense. These are liable to be lost with the narrowly and one-sidedly educated man and woman.

2. Training in morals, in citizenship and in economics as part of industrial education is more and more demanded, and rightly so. But mere formal academic lectures, essays, admonitions to be good and mutually helpful and patriotic do little good and are a waste of time. The success of teaching morals. citizenship and economics depends upon the school and teacher to so unite the intellectual part of industrial education with the vocational, or occupational part and interests of the young people, that they become conscious of the inseparable interdependence between their individual actions and desires with the aims and purposes of the community they live in. That is to say; the work which the young people are to do in school, in the industrial school in our case, must be so taught in order to make them feel and

understand that their daily and hourly activity contributes not only to their own individual subsistence and contentment but at the same time determines the prosperity and welfare of the community. Since they themselves cannot live and work without the community being prosperous, orderly and peaceful, their work must not only be efficient but their lives must be moral, economical and helpful to society.

APPENDIX I.

What the Foundries Can Do.

While there is no prospect at present for foundries getting their boys and young men prepared to learn the foundry trade and to carry it on as an occupation for life, the foundries have an opportunity to do something themselves to relieve the situation. The problem is not so much to get boys with a specific trade training, because boys who have passed through schools where such training is given will not stay permanently as molders in the foundries, but to get boys with some degree of developed general intelligence, or to develop that intelligence while they are at work. Conditions are more favorable now to do this with the co-operation of the schools, than they were last year or the year before. States, municipalities and the school people are more ready to help the industries than they were formerly.

The first step is to put foundries and work shops in as good sanitary and clean condition as is possible and insist upon them being kept so. Hygienic, charitable, child-labor and similar congresses are continually educating the people up to the necessity of healthy surroundings and at the same time proving, in one way or another, how the physical efficiency and therefore the productive capacity of the worker in shop, store, and office is increased. Ever since 1889 a constant stream of foreign engineers and manufacturers and professional men has passed through our country and your chairman has had the pleasure to meet more than three hundred of them.

Those of these visitors whom he met in Altoona, and nearly all came there, naturally wanted to see the great railroad shops where a total of some 11,000 men are employed. The Juniata shops, where new locomotives are built, never failed to attract the attention and to elicit praise because of the cheerful environment, healthy location with its light, airy and sanitary condition. Hundreds of times has your chairman asked these visitors what they judged to be the value of these clean, and healthy surroundings, expressed in increased productive capacity and better work.

Many of these engineers were well able to give an intelligent answer to such a question and none estimated the extra productive value of such and similar healthy shop surroundings at less than five per cent and sometimes as high as ten per cent. Hence, whatever lessens the unavoidable presence of dust and dirt and other depressing influences in a shop and, on the other hand, whatever contributes to create cheerfulness and contentment with the surroundings of one's working place is not only a direct material gain but a distinct indirect ethical gain. However keen the competition and however great the intense pressure for output, it would be a mistake to ignore entirely the ethical side and influences as related to workshop surroundings.

Who is ready to deny the hundred and one instances where irritation was caused by objectionable but remediable surroundings in the shops. These cause lack of discipline and slackening of confidence which in turn necessitates disciplinary measures with increased irritation and consequent widening of the gulf between employee and employer, and lowering of the moral tone, avoidable, or at least modifiable in the first place by a judicious consideration of surroundings.

At the recent teachers' summer school at the Pennsylvania State College one of the topics discussed was: To what extent do airy buildings, pleasant surroundings and sanitary conditions contribute to the efficiency of the school? And if such influences, modified of course in a shop, react favorably upon the boy and girl in the school room, they are likely to react favorably upon the mind of the boy and young man, and old man, in the shop notwithstanding of the drawbacks of foundry conditions.

Next, the foundrymen should insist in their localities upon the beginning of a preparation, in the seventh and eighth grade of

the schools, for industrial life of the ninety who do not go to the high school or stay there only a year to two and then go to work.

The school people are much more willing to listen to such a proposition now than formerly and differentiation of courses in the seventh and eighth grade to meet the demands of industrial life, has been frequently discussed lately in teachers' conventions.

It is admitted that such a change would hold many of the fifty per cent who now drop out at fourteen years with a sixth and seventh grade education only. This holding of the children in school would in itself contribute to increased intelligence.

Extensively conducted investigation has shown that of the children rushing to work at fourteen years of age only twenty-five per cent do so from sheer necessity to earn something. Thirty-five per cent go to work because the parents want them to do so, and the rest drop out and go to work because they are tired of the book drill in the school. Here an intelligent interest of the foundrymen in school matters will help the school and the community and will react favorably upon their shops and trade.

The differentiated courses in the seventh and eighth grades should be so shaped that the boy and girl get some insight into the life of the world outside of the school room, and manual training in the grades could thus be made the nucleus around which to build up this elementary conception of the world which interest the boy so much at that age. Hence the desirability of the industrial people and the school people coming together to exchange notes.

While our traditional elementary school emphasized mental development to the exclusion of the world outside of the school room, the necessities of the hour for training millions for occupational life make a reversal of the former process desirable by introducing the ninety out of every hundred children, destined to make a living by their hands, to the real things of life without at the same time endangering the cultural mission of the school. That this can be done has been repeatedly asserted by many educators. They ought to unite now upon a way how to do it.

APPENDIX II.

CONTINUATION (IMPROVEMENT) SCHOOLS.

The United States Bureau of Education has recently issued a pamphlet, Bulletin No. 19, 1913, whole number 529, on, "German Industrial Education and its Lessons for the United States."

Part 1 describes the activities in the United States along lines of vocational training through the medium of apprenticeship, shop schools, school shops and the various forms of industrial schools, and the results and omissions of our industrial education.

Part 2 describes the nature and results of German industrial education.

Part 3 draws conclusions from the foregoing.

These conclusions state elaborately and with governmental authority what your Committee on Industrial Education has recommended for years as essential for the retention of the industrial and economic standing of the United States, and for the preservation of our civilization against the enervating and demoralizing consequences of excessive specialization of work of all kinds and automatic machinery, unavoidable though these may be. There are thus produced millions of semi-skilled and unskilled workers who must contribute their share to the general welfare of the community as well as the skilled and highly educated citizens.

If the value of these lessons, as presented by the government report, have thus far received little attention it is because these consequences, being the reverse side of the inspiring picture of our phenomenal industrial development, have not yet forced themselves very strongly upon our attention. The presentation of these lessons by the government is timely inasmuch as there is already a strong movement in this country in favor of the creation of a system of continuation, or improvement, schools, as the government report calls them, which are intended to do justice to the millions of industrial workers of all kinds, of both sexes, for whom there is no provision at present whatever.

It is partly because the manufacturers have thus far paid hardly any attention to this serious phase of the industrial educa-

tional question, demanding from the schools only skilled workers for increase of productive capacity, that the school people have conceived the idea as if the industries had no other object but to commercialize the public schools.

Several States have already passed laws, favoring the establishment of continuation schools, and if the foundrymen co-operate with the school authorities in their respective localities in encouraging this movement, then it will be an additional help to get better prepared boys and young men into the foundries.

A further inducement in this direction would be an increase in apprentice or young journeymen's wages for those who have made good use of these schools. Such liberal action would in turn react favorably upon the industrial schools, provided the industries would follow intelligently the quality and quantity of the output of the schools, not to have this output too academic on the one hand, and not too narrowly mechanical on the other hand. Cincinnati, Boston, Chicago and Buffalo have very commendable types of such continuation or improvement schools.

The course of study would be more general and less mechanical and more of civics and the relation of industries and industrial life to the life of the communities, during the first year, and dealing more with the mechanical part and elementary technical knowledge of the industries the second year. This would give the gifted and talented ones a chance to climb to the top, giving an opportunity to all alike, and serve as a preparation for the higher grades of industrial education.

APPENDIX III.

Tentative Plan for Foundry Apprentice School (Four to Six Hours per Week).

Two hours per week reading and composition during entire apprenticeship. Reading to include trade journals and description of business trips at home and abroad with general discussions and explanations of particular points. Composition to include writing of business letters of various kinds. Likewise descriptions of shop experiences and giving expression concerning impressions received during visits to other works.

Arithmetic.

Application of the fundamentals of arithmetic in calculating cost of raw material, freight, time to perform given jobs, loss or gain on these jobs, taxes, wages, per cent of wages, of time, of raw material to total cost of finished product. Estimates of cost of production per piece, per hour, per hundred or thousand pieces.

Elements of Bookkeeping.

Meaning of day book, cash book, ledger. inventory, expense book, etc.

Drawing.

Mechanical drawing and particularly how to make working drawings and sketches of single parts of machinery and broken parts.

Materials.

Raw materials used in making iron and steel; where found and extent of supply; how they are converted into metals. The blast furnace. Bessemer process. Open-hearth processes. Crucible process. Electric furnace. Cupola. Puddling furnace. Pig iron, wrought iron, malleable iron. Bessemer, Open-hearth, crucible steel. Special or high-speed steel. Annealing, hardening and tempering. Copper, zinc, tin, lead, aluminum; how produced. Alloys, brass, bronze, etc. Coal and coke; where found and how produced. Wood, different kinds, and where found. Properties of woods. Diseases of woods.

Some elementary knowledge of the chemical and physical properties of metals. Mixing of iron. Molding sand, where found and its qualities for the foundry. Cores and their uses. Melting. Patterns of wood and different metals.

Elementary Physics and Mechanics.

Physical and mechanical laws. Heat, light, steam, electricity, motion, inert combustion, evaporation. Steam, electrical, water, gas and combustion motors.

Social Economy.

Dangers to be avoided. Prevention of accidents. First aid in accidents. Insurance. Value of hygiene and sanitation. Temperance in eating, drinking and smoking. History of the trade and of the development of our industries generally. Kind of resources upon which our country depends to sustain industry. Where they are found and what part these resources played in the development of different parts of the country and what part they may play in the future in the development of the country.

To what extent do our resources enable this country to compete with other countries. Transportation and its influence in developing our industries and agriculture through the easy distribution of raw material, finished products and crops. Exports and imports. Transportation facilities of competing countries.

SOME OBSERVATIONS ON MINIATURE OR DETACHABLE OPEN-HEARTH FURNACES.

By W. M. Carr, Erie, Pa.

When the idea of a small, portable open-hearth furnace was conceived, the principal object was to reduce to a small scale all of the advantages of standard open-hearth practice and apply them to the production of small, intermittent tonnages of liquid steel supplied by other processes having certain irregularities in operation and quality of product, conspicuous by their absence in the methods of the above named and deemed sufficiently valuable to emulate. Writing after an intimate experience of almost three years' duration with the practical application of the miniature open hearths, ranging in capacity from one to two and a half tons per heat, the essence of the original conception has been justified by the results obtained and the opening up of a new line of thought, deduced from such an experience is offered, a hint of which can only be presented in a paper such as this and on an occasion of this nature. In other words, the original attempts were crude, but with time some points worthy of consideration by all those interested in metallurgy have presented themselves, and which were not anticipated at the outset. It is the purpose of this paper to put the salient features before you, resulting from a new application of steel-melting furnaces, and which properly can be called improvements.

For the benefit of those present who may not be familiar with the dominant idea, this consists of a small open-hearth furnace whose body is cylindrical and capable of holding 1 to 2½ tons of liquid steel. The body is detachable from the flue connections and may be suspended from a crane or other suitable mechanical arrangement and moved from mold to mold while its contents are being tapped into them. No ladle is used, as the furnace body acts as a melting chamber and pouring ladle. The flow of metal is controlled by the usual form of stopper and

nozzle. The nozzle is set in the back wall during melting operations and the stopper passed through the charging door shortly before tapping. The position of the nozzle is above the slag line with the furnace body in melting position, but the operation of lifting away from the ports or flue connections gives the body a quarter turn which brings the nozzle then to the lowest point. That is to say, the stopper fittings are set in a horizontal position, but when tapping the stopper rod is vertical. The setting of the stopper rod gives the opportunity to see from the tapping side whether or not the stopper head has properly seated itself in the nozzle and if while rolling over there is a suggestion of a leak the furnace can be rolled back to normal and the stopper re-set. This gives an assurance of regularity in pouring or tapping not found in the common bottom pour ladle. The method of pouring as described is simple and a leak from an imperfectly set nozzle has never occurred in the author's experience. The general arrangement will be understood by reference to the cuts of the furnace in melting and tapping positions. The melting operations—that is charging, melting, boiling and refining the liquid metal—are the same as in standard open-hearth practice and for the purposes of comparison. reference will be made to that throughout this paper. The quality of open-hearth product is so well known that standard open-hearth practice can be safely used as a criterion and that the deductions herein brought out can fittingly be applied to other methods of steel making, since they too must refer to the recognized standard to substantiate their claims. In spite of the fact that standard open-hearth methods do afford opportunities to produce high quality product, there remain certain elements of weakness the effect of which is the introduction of variables. Writing from an intimate acquaintance with these variables, the author believes that their occurrence may be very materially reduced if certain precautions are observed, and he has the conviction, strengthened by observation and experiment, that the observations offered in this paper at least point a way to the solution of the causes for the variables in steel making presenting themselves at the most inopportune occasions. For the sake of comparison the least controllable objections existing in standard open-hearth practice are given as follows:

1. Standard open hearths must be kept under continuous heat to prevent collapse. In case of idle periods this entails expense (crucible, Bessemer and electrical processes excepted).

2. Owing to prolonged casting periods with large melting units, segregation is set up and this feature will vary with the number of molds to cast at a given time or whether the charge goes into one mold only, as in armor plate practice; also with the volume of metal in the charge, the casting temperature, and whether the practice is acid or basic. Segregation in the latter is more pronounced with some elements than in the former.

FIG. 1.—CARR'S DETACHABLE OPEN-HEARTH FURNACE. MELTING POSITION.

3. In cases where it is desired that two or more heats are to be of a given chemical composition, variations are caused (*a*) by slag interference when ladle additions are made, and (*b*) if made in the furnace by improper solution and diffusion of the elements added, both conditions in turn effected at the time of and following the ladle transference of the charge by what may be termed "secondary oxidization." This phase, while unavoidable under all steel-making processes (excepting portable open-hearth and crucible melting), really is responsible for more failures in product than others. Consider for a moment the care, patience

and skill exercised in getting a heat of steel into condition to tap. The tapping period has arrived. The operator is furnished with a ladle which may or may not be dry. In any event it is a good deal cooler than the furnace in which the charge is treated. While the temperature of the ladle may not have a direct effect upon the chemical composition of the metal it may contain, it nevertheless causes variations in a mechanical way leading to losses that are undesirable in the sense that they defeat regularity in operation. Regularity in quantity is just as commercially necessary as that of quality. The heat is tapped from the furnace; the liquid steel flows into the ladle, but during its passage through the atmosphere it absorbs oxygen, is again oxidized although the operator spent time and effort to deoxidize the metal before tapping. The stream of metal entrains air. That is apparent. There are gases introduced that were not present before. Drawing water into a bucket from a spiggot is an analogy. The steel is undoubtedly harmed, and the product may or may not pass inspection. Sometimes the product has been partly fabricated or may have been in service. Loss of human life may have occurred. Hidden flaws were responsible and which did not appear in all the tests made at the mill to prevent them, or rather used to detect them in the first instance. Certain elements may be introduced into the molten steel to offset the bad effects considered. Why not change the method of pouring and eliminate subsequent doctoring with its trail of uncertainties? Is it any wonder that blow-holes are found in steel castings, snakes in sheets and pipes in bars or rails?

4. Variations in tapping temperatures. These conditions have a pronounced effect upon the physical properties of the finished product to a greater extent than is generally recognized. They are related to the necessity of superheating the bath of metal to reach and maintain a desirable temperature before ladle transference and casting into molds. If the volume is small the superheating must be greater, for then the chilling effect of a cooler ladle is greater; and, per contra, the larger the volume the less will be the chilling and the longer can the casting period be prolonged. By superheating molten metal is meant that elevation above the actual melting point in order to have enough fluidity to readily flow from the vessel in which

it may have been melted. In steel melting the range of elevation of temperature has never been fixed. That it can be carried too far there is no doubt, and just what the range should be there does not appear a rule to lay down, and therefore, general terms must be employed. It has been distinctly impressed upon the author that the matter of superheating holds within itself the explanation of numerous problems that very often are passed over as belonging to the category of "the personal equation." That term is frequently used when a failure occurs to secure a pre-determined degree of uniformity in two or more heats. It

FIG. 2.—CARR'S DETACHABLE OPEN-HEARTH FURNACE. POURING POSITION.

is used because theoretical knowledge has not taken into account all of the factors entering into metallurgical problems, although we have efficient chemists and metallurgists, fixed methods of tests and inspection, and the valuable assistance of practical operators. The necessity of limiting superheating has not been recognized sufficiently to express it in definite terms. It is roughly limited by the refractoriness of the lining of the container on one hand and on the other by the operator's visual sense of the metal's fluidity. It is certain that if the container were more refractory that the melter would carry superheating still further, as he is prompted by a desire to see ladles free from skulls and

no misruns in castings. It may be fixed in the upper limit by a pyrometric measurement and that limit used as a reference for succeeding heats of the same grade, but uniformity is not enough in that particular. Granting that an upper limit could be fixed by such means, it must of necessity be governed by the fact that the metal will be cooled by an indefinite and indeterminable drop in temperature, through transference to a ladle heated to an equally indefinite though lower degree. The variants are too obvious to need elaboration.

What are the effects upon the physical properties of finished product? It is very evident that the phenomena of brittle steel, poor bending tests, low tensile strength, coarse fractures and failures in service are not explained in regard to the causes for them by chemical analyses, microscopical examinations of the structures, or the study of the history of the processes as given in heat records. It is too well known that a given heat of steel may meet all of the necessary tests and safeguards thrown around it and yet a succeeding one made in the same furnace, by the same operators, the same stock and tested chemically to equal the one preceding and yet fail possibly in the matter of bending or other tests. "Personal equation" as an excuse does not satisfy. Ignorance of the effect of superheating comes into prominence and if that were better understood there would be less uncertainty. It is not absent even in crucible melting, even though the steel is cast directly into molds without the intervening ladle, yet superheating is vitally necessary because of the very small volume per unit. In Bessemer practice the phenomenon is characteristic. The author is convinced that if the phase of superheating be carried out without the fear of skulls and mis-runs that the irregularities now so frequent would be of less annoyance. In other words, putting the matter briefly, steels made by other processes are tapped too hot. The variants accompanying superheating, combined with those touched upon in the preceding section, make the art of steel making less laudable than appears upon the surface.

We can now consider suggestions that carry in a measure at least some relief, and as pointed out are the conclusions based on a knowledge of portable open hearths. The advantages presented by them will be considered in the same sequence as

the disadvantages of standard practice as given in the preceding paragraphs:

1. Miniature open hearths of the portable type do successfully withstand alternate heating and cooling without damage. The ports, regenerator chambers, checkers, collecting flues and stack can be lined with first quality fire-clay brick. The structures mentioned do give every evidence of permanence. The furnace body is lined with blocks of mica-schist roughly cut out approximately the length of a standard size brick. After being dried and brought up to full working temperature, silica sand

FIG. 3.—CARR'S DETACHABLE OPEN-HEARTH FURNACE. POURING POSITION.

is set over the face of the lining throughout. The body being cylindrical has not the parts known as roof, side walls and bottom as in the case of the usual form of open hearth. The body, being also revolvable as well as portable, it is a simple matter to set circumferentially, a thoroughly refractory surface exposed to flame action, radiation and the effect of liquid steel. Mica-schist is refractory, resists the action of an acid slag and is indifferent to sudden heating and cooling. It is perhaps the first time that open-hearths have so been lined with the material mentioned, although it is common practice in the earlier types of bottom-blown Bessemer converters. The cost is practically

one-third that of brickwork and is much more efficient in service. With two shells or bodies per furnace, repairs can be quickly made by having on hand one spare body fully lined and prepared for melting. This saves much time over the usual method of laying the furnace off during repairs to the hearth. So far as general repairs are concerned, it is a matter of indifference as to whether the furnace is kept working daily or irregularly. The question of expansion and contraction does not enter into the problem at all. Therefore the miniature portable open-hearth furnace possesses advantages over the standard type in the respects considered.

2. The problem of segregation is reduced to practically a negligible quantity in the types of small open hearths herein considered. The cause of the desirable effect is due mainly to the lesser volume over the standard sizes. The casting period being much shorter in duration, also plays a part. This is also true of any process producing steel in quantities equal to or less than the type of furnace advocated by the writer. In his experience with portable open hearths he has had a great many analyses made on samples taken at the first and the last of a cast in numerous heats of various compositions, which proved that segregation was practically absent and that when differences did occur they could be traced to negligible errors in chemical manipulation. It is the practice to make all the additions in the furnace; this is self-evident, as no ladle is used. But by so doing with the bath under flame sustenance so far as temperature is concerned there is offered the opportunity to get an even distribution and solution of the deoxidizers and alloys, assisted by mechanical stirring by rods or by rolling the furnace body. Segregation is also lessened by the fact that secondary oxidation being absent, the ladle stage of steel making eliminated, there is no change in the composition after solution of the additions of whatever kind is complete. This, then, assures uniformity throughout the mass because the reactions have ceased before casting.. In a ladle they continue because of entrained oxygen which assists segregation so long as the mass stays fluid. It will be thus seen that a small volume of steel cast directly into molds without ladle transference gives better results in uniformity than larger melting units.

3. The disadvantages mentioned in the corresponding paragraph are absent in portable open hearths. The charge has the benefit of protection from slag contamination as the metal is discharged from below the slag, that is, from the lowest point of the furnace, and as all additions are made in the furnace with the possibility and certainty of thorough solution, there is no possibility of slag interference preceding and during the casting period, which is conducted directly from the furnace into the molds. Secondary oxidization is therefore absent since no air entrainment happens as in tapping into a ladle.

In this respect the conditions are almost identical with crucible melting and casting; that is, small volume assuring uni-

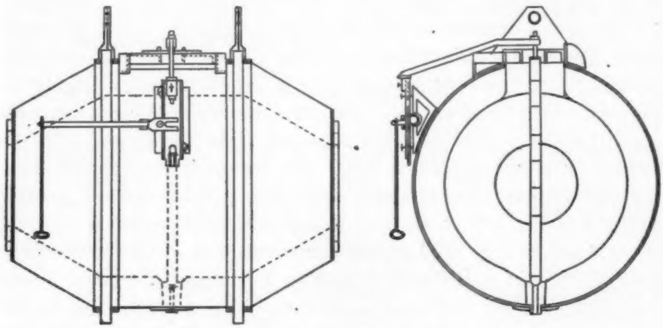


FIG. 4.—CARR'S DETACHABLE OPEN-HEARTH FURNACE. STOPPER IN POURING POSITION.

formity in composition, a protective slag covering throughout the process and casting direct from the pot into the mold.

The uncertainty of cold ladles is entirely absent; there is no undue chilling of the steel and the loss from ladle skulls is eliminated.

The prevention of leaky stoppers or nozzles has been described.

The physical properties of the product possesses qualities not found in standard open-hearth material. The high quality and purity is of the best.

4. In the matter of temperature variations following ladle transference and the preceding superheatings in standard open-

hearths, crucible, Bessemer or electrical processes, an entirely new set of conditions is obtained with portable open hearths. As previously mentioned, the furnace body acting at once as a combined melting and pouring vessel, the consideration of what the effect of a ladle might be is not a factor in the case at all. The necessity of extreme superheating disappears for that reason. Though the volume is comparatively small, which under ordinary circumstances would compel particular attention in seeing that the fluidity of the metal was high and the temperature excessive, in this case the small volume does not operate in that direction. Contradictory as it may seem, it is a fact that the portable open hearth, even with a charge of only 4,000 lbs., can be operated at a much lower temperature than any process in existence. To the eye of an experienced operator in other steel-making processes, the characteristics of the steel described would certainly be said to be too cold to cast. In a practical way, judging by the ordinary "test-spoon" test, the metal made by portable open hearths is sluggish and does not clear the spoon. In the writer's earlier experience with the furnaces under consideration the impulse was to reach as high a temperature as possible and unless the test-spoon was free from chilled metal it was not hot enough to tap. Subsequent observation showed the needlessness of extreme superheating and that casting at a much lower temperature than had ever been followed elsewhere, and in the judgment of others a departure from usual practice, enabled the castings of thin, light sections a possibility, a freedom from skulls in the furnace, and physical properties that cannot be surpassed. The practice is a distinct departure and can be called "low temperature steel making," in contra-distinction to superheating by regenerative means in standard open hearths, the well-known high blowing temperatures in side-blown Bessemers, the arc temperatures of the electrical and incandescence of the crucible processes.

Concerning the physical properties of steel produced by portable open hearths, the characteristics are: Freedom from occluded gases, absence of red shortness and cold shortness, uniformity in composition throughout a given mass and the same feature repeated in two or more heats of a given composition, all leaning towards greater regularity in practice than is

otherwise obtainable. One feature assisting in arriving at regularity in successive compositions is that of a low and but slightly variable melting loss, and this, together with a deliberate "hasteless" operation of the furnaces, approaches that ultimatum which stands for quality rather than a sacrifice of it by yielding to the quantity impulse, unfortunately too prevalent on this side of the Atlantic.

In support of the claim of superiority in physical properties the following tests are given. They were made by Mr. Edwin F. Cone, formerly Engineer of Tests for the American Steel Foundries, of Thurlow, Pa. (and they are offered as evidence because they are from the hands of a disinterested party), on test bars furnished him by the author, and were published in the *Iron Age* on February 27, 1913:

UNANNEALED SPECIMENS.

	No. 1.	No. 2.
Tensile strength	61,220 lbs.	61,530 lbs.
Elastic limit	39,800 "	....
Elongation in 2 ins	16%	21%
Reduction of area	18.8%	22%
Elastic ratio	65.01	....

	PARTLY ANNEALED.		THOROUGHLY ANNEALED.	
	No. 3.	No. 4.	No. 5.	No. 6.
Tensile strength	65,000 lbs.	65,480 lbs.	61,500 lbs.	62,000 lbs.
Elastic limit	43,000 "	41,620 "	34,500 "	35,000 "
Elongation in 2 ins.	25.5%	24%	32%	31%
Reduction of area	35.7%	33%	58.6%	57.3%
Elastic ratio	66.15	63.56	56.09	56.45

The analysis also made by Mr. Cone on the above-mentioned specimens is as follows:

Carbon	0.21
Manganese	Trace
Silicon	0.436
Sulphur	0.035
Phosphorus	0.063

To quote his remarks further:

"Any of these tests are good and compare favorably with any regular open-hearth or other carbon steel having the usual

manganese content of 0.60 to 0.80 per cent. Especially fine are tests five and six . . . they surpass the usual run of acid open-hearth metal in elastic ratio, which usually averages 50 to 52 per cent only. It is also noticeable that the elastic ratio of this steel in any condition is above the average.

Under the microscope . . . I examined it very carefully for oxides and slag, and in a marked degree it was free from these impurities. It is the common impression that any steel made in a baby (small, portable) open-hearth furnace must of necessity be considerably oxidized. But here is a steel made without the use of manganese . . . a steel as good in quality and properties as any other.

"There is a large demand for any method that will produce small steel castings economically and of first-class quality."

The notable feature about steel of the kind examined as above is that it can be made without manganese. The writer in his practice established that first-class open-hearth steel could be made without that deoxidizer deemed so necessary in daily practice with other methods. The departure was followed for seven months before it was published, as it was seen to be heterodox and unless sure of his ground would entail criticism and condemnation. The evidence was ample and thoroughly sustained by trial and experiment. The fact that manganese can be discarded supports the author's claims that steel made by the portable open-hearth furnace is not damaged, contaminated nor injured by steps now unavoidable in standard open-hearth methods, or others not following the advantages offered by the type under consideration. That *low temperature melting* and tapping conditions, while permitting the successful pouring small steel castings heretofore thought out of the open-hearth field, and yielding a steel that is devoid practically of red-shortness or liability to manifest hot cracks, and yet be produced without the use of plural deoxidizers (manganese, aluminum or titanium) certainly indicates an advance in steel-melting methods. That silicon alone will thoroughly quiet a bath of small open-hearth steel approaches the much desired "dead melt" of the crucible process, provided that the steel was not superheated nor over-oxidized in melting. This freedom from over-oxidization is not existent because of a small open hearth, but rather due to the fact that the metal is not abused in preparing it to transfer to a

ladle. That is the essence of the matter. It has been suggested by enthusiastic onlookers of the small portable hearth, who were gifted with a more vivid imagination than the writer, that the method can be applied to larger capacity furnaces to secure the benefit of the direct casting plan.

On a commercial scale the type of furnace under consideration will fit in admirably in a steel foundry already equipped with the heavier capacity furnaces. It is not infrequent that steel foundries receive inquiries for special composition steel castings in quantities much less than the capacity of a single furnace. As a consequence a customer is lost. In such a plant there is the open-hearth crew in sympathy with open-hearth methods and no additional equipment need be bought to adapt one or two of the furnaces. The borders of the concern could thus be enlarged and a greater variety of customers could be accommodated.

In another case, a wholly new establishment could make use of the smaller melting units for the sake of flexibility in practice. It is better to divide the capacity of the shop into as great a number of melting units as possible than one or two only. There occur slack periods in the volume of business. Orders may fall off sufficiently to perhaps require one large furnace to cast every other day. This results in an excessive fuel bill. With smaller units the number of casts could be increased and quicker deliveries could be made of the product. On the one hand the furnace is waiting for the molding floor to get enough molds on the floor to take a heat, in the other plan the molding floor and the furnace department could keep better pace together. Furthermore, increasing the number of units permits an approach to continuous operation now much sought after in foundry practice. It is better to cast frequently from small heats, thus clearing the molding floor of used molds and make room for a succeeding lot of fresh ones, in preference to covering a large amount of floor space with enough molds to take care of a fewer number of heats each of greater tonnage. The author does not claim anything original in this proposal.

It was stated by one of the leading steel foundry proprietors in the West that the ideal plan would be eight of these portable open-hearth furnaces of about four tons capacity per heat, and

that he could turn out as much, if not more, with these than with two furnaces of twenty tons capacity per heat, and at the same time give a greater variety of compositions and weights per piece. And this also with more speed in production and with less molding floor space.

In view of the advantages of the type of furnace advocated, this suggestion seems worthy of attention, and should also appeal to the malleable iron casting industry. The same features of frequent clearing of the casting floor is afforded, besides the manifest gain in fuel economy of regenerative furnaces over direct-fired air furnaces. (Space will not permit a fuller examination of item of furnace comparisons in regard to the values of direct or regenerative firing.)

In regard to steel making the advantages can be summarized as follows: The cost of installation is less than that of other methods, excepting only the crucible furnaces. The cost of operation per pound of metal melted is second only to standard open-hearth practice. Compared to other processes on a given output it has distinct advantages and economies. The quality of product is strictly high grade, compares favorably with that of any other process in freedom from porosity, brittleness, uniformity in composition, and can show a higher plane of physical properties than any other carbon steel, as evidenced by the usually high elastic ratio of tensile strength, otherwise obtained by steels treated by the additions of rare metals. Mr. Cone's test shows a range from 56.45 per cent to 66.15 per cent, depending upon the heat treatment of the specimens. That there is no difficulty in meeting standard specifications in any particular and that the castings will stand abuse and distortion as readily and spectacularly as those made by any other method. The melting loss is much less than the Bessemer or converter process. This feature is the principal economic advantage over the latter. Its warmest advocates of the converter process admit between 15 and 30 per cent loss, while standard open hearth will not exceed 12 per cent under the most unfavorable conditions. The average is 8 per cent. In the portable open hearth the range is from 6 to 10 per cent. The author has never exceeded 10 per cent as a maximum melting loss. The economic advantage over the Bessemer sideblown process is obvious.

Cast-Iron Melting.

The use of the portable open hearth as a melting unit in a gray iron foundry for the production of iron castings may seem an innovation. The cupola has been with us a long time and is looked upon as a necessary adjunct to a gray iron shop. It is conceded that as a means of rapidly melting iron it cannot be surpassed, but as a device offering certainty of operation, a positive control of product in regard to composition reads into the story another element of research more or less problematical.

Undoubtedly great improvements have been made and are being accomplished, but its supporters will concede that a charge once melted preparatory to tapping cannot be changed only by re-melting. In other words, there is no way with a cupola to determine whether or not the melted charge conforms to a desired composition. A charge may be carefully compiled to suit a given condition, but when it is melted there is not always that comforting assurance that the castings will bear inspection or comply with given requirements. Here then is an avowed weakness of a cupola. Then again there is the ever-present absorption of sulphur from the fuel. That goes on as an ever-increasing increment with each charge of returned shop scrap until its disposition becomes another problem of the future. All the fluxes, doses and neutralizers fail to ameliorate this condition.

Just so long as the consumption of gray iron castings goes on under specifications formulated with due regard for cupola limitations will the cupola exist as an instrument for melting, but as the demand for malleable and steel castings increases the specifications for gray iron castings will become more rigid, then a more flexible and dependable melting means will be sought. That this situation is approaching if not already here is manifest. It is at this juncture then that the advantages of the open hearth can be advanced.

In the open hearth the whole charge is melted at once and it can be made up on an analysis basis to meet any given composition. Then after the charge is melted, tests can be conducted to determine the depth of chill if needed, the silicon content, the temperature can be judged and other conditions can be gauged and adjusted and any necessary changes can be made by adding to or boiling out of the bath by slag action, etc., before tapping. This

assures greater control of composition and tapping conditions than is offered by a cupola. Not only will the metal be cleaner and stronger, but it will be freer from sulphur and its objections. Metal melted under such conditions is admirably adapted to cylinders, piston rings, ammonia fittings and others where density of grain is important and freedom from porosity necessary.

The mechanical advantages of a portable open hearth is the ability to bottom-pour molds, thus keeping out of them all the kish, dirt and slag that gathers on the surface of a bath of cast iron and which is frequently carried through the gates, causing defects in the castings.

In the matter of economy it is true that the open hearth is slower in melting than the cupola, but that can be offset by a number of furnaces charged to space taps and divide the cast into several intervals as against one of the cupola. In labor cost the rate per ton is the same and the fuel ratio will be governed by the variety used, which may be oil, producer, by-product or natural gas. The well-known advantages of air furnaces over a cupola need no elaboration, but the thought here is to present the open hearth as a step in advance of the air furnace, mainly because there is a greater saving in fuel and more certainty in flame control and temperature conditions. The open-hearth is not advocated as an immediate successor to the cupola. The latter has its place, but in cases where higher grade product is demanded than can be furnished by a cupola the open hearth will fill the need.

The author has had an extensive experience in melting gray iron with natural gas in a portable open hearth. The quality of the castings so made can command a premium over cupola metal. The fuel is ideal and in localities where coke because of haulage charges becomes costly, then natural gas, if available, is a most desirable substitute. This is worthy of consideration by foundries in the West or Northwest where natural gas is abundant and coke a luxury. With the regenerative features of the open hearth the maximum economy can be reached and the cost of natural gas over coke will under such conditions show distinct advantages. The use of natural gas as a substitute for coke, while unusual, does without doubt open a new field in gray iron practice.

HOW TO MAKE A TIME STUDY.

BY C. E. KNOEFPEL, NEW YORK CITY.

If a man prepared an elaborate treatise on "How to Scale the Alps" when people did not particularly care for mountain climbing, he would do little beyond contributing to the literature of the day. If, however, he could first convincingly outline the beauties and benefits of Alpine trips, his guide book would then be a decided convenience.

This is exactly how I feel about the subject I have set out to discuss. What a "time study" is, and why it is a most essential factor in any scheme of efficient management, is as important as a description in regards to how a time study is made.

AN ILLUSTRATION OF THE POSSIBILITIES.

In a recent issue of the *American Magazine*, Frank Barkley Copley told how at the Watertown (Mass.) Arsenal, a time study expert investigated the molding of pommels for pack saddles. The average making time was 53 minutes per mold. After the proper study and analysis the operation was standardized and a time of 24 minutes decided upon—a reduction of 29 minutes. He states that the first man who worked on the schedule had no trouble in making the molds day after day, in an average time of 20 minutes each and to show what could be done, if the man wanted to see how far he could go, he made the molds for one day at the rate of 16 minutes each and one mold was actually made in 10 minutes. The cost to the Government was reduced from $1.17 to $0.54, while the earnings of the molder increased from $3.28 to $5.74.

This means one of two things: 1. Either the operation was so inefficient that any ordinary molder could, without difficulty, decrease the working time 62 per cent as in this case cited, or 2. There must be wonderful possibilities in time study work.

Another Illustration.

In one of the large steel foundries located in what is probably the greatest iron and steel center in the country, it was found that the molding time on a certain casting was 147 hours. The work was studied and the time standardized at 85 hours. The men made these castings in 92 hours each, with the following results:

Decrease in time	32½ per cent
Decrease in cost	30 "
Increase in production	60.1 "
Increase in earnings of men	12 "

The shop in question had been operating for a long period of years and its efficiency would compare favorably with the average foundry the writer has been in. The illustration, moreover, is not an isolated case.

If it is glaring inefficiency which makes it easy to effect these surprising improvements, *then why is it that the gains were not made until after time study work began?* If work is so easy to better, why defer the betterment? The first conclusion will hardly stand a fair analysis, for all the evidence to date proves conclusively that it is the method of time analysis which discloses what and where the faults are.

Why Time Study is Necessary.

As practical foundrymen, who have given years of study to your work, you naturally want to know why this is so. Two years ago in my paper for your Convention on "The Efficiency Movement in the Foundry," I made the following statement:

"By those who have had the opportunity through actual experience of studying the conditions as they exist, two conclusions have been reached:

"1. That a man can accomplish considerably more than he does.

"2. That the management as business is at present conducted does not know what constitutes the best a man can do."

What is work? In a purely scientific sense it is the merging of men and conditions to form a harmonious arrangement which will most efficiently produce the desired results. The foundry

business is sometimes considered a simple proposition, yet when resolved into its elements it assumes altogether different proportions. There is the shoveling, ramming, setting gaggers, coring, finishing, closing, pouring and cleaning. There is the making of cores for the different kinds of work. There is also the metal to be melted and properly poured. The rigging used is an important consideration. There must consequently be the proper adjustment of men with these various conditions, or results will not be all that are possible. This you will all admit.

The chemist; metal specifications; the improvement in cupola practice; the rapid advance in molding machinery; the study of the coke problem, transportation facilities and labor saving devices, have all combined to materially better the work done in your industry. But how about the man side of it all? *Have you studied him to the same extent that you have studied the physical forces with which you deal?*

Analysis of Industry.

Let us analyze for a few moments, even if it may seem superfluous, for I am leading up to an important point. There are three factors in the adjustment of men and conditions referred to:

1. The Executive Management.
2. The Shop Management.
3. The Workmen.

Take the executive management, for instance. The manager is usually a very busy man. He must watch the markets so as to purchase his materials to best advantage. He must see to it that his shop is filled with orders at the best prices he can secure. The matter of credits and collecting the money due must be constantly watched. The manager must be both a diplomat and a judge to consider and pass upon the complaints from the trade and settle the disputes that arise within his organization. Pushing the work through the shops, watching the quality of the product, studying the costs and statistics furnished him are other matters to which he must give attention. Add to these the other countless details which he must supervise, if not direct, and it is manifestly impossible to expect him to study, in a detailed manner, what each man or piece of equipment is doing,

and whether it is done efficiently or not. It is usually not considered necessary to do so, even if it were possible, in view of the fact that a shop organization is maintained for receiving the orders to make what is sold.

The superintendent is likewise a much burdened man. He must maintain a force of men to turn out what is wanted. There is the assigning of the work to the men; seeing that they are supplied with what they require to enable them to work to advantage. The superintendent must set piece rates and adjust wage differences with the men. He is naturally responsible for the melting operations and the quality of the product. He must give attention to rejections from day to day and the complaints from the trade about errors and poor material or workmanship. He must make every effort to make prompt deliveries. If men quit he is expected to fill up the gap as quickly as possible with the best material he can secure. He must advise his men regarding molding and gating methods, and supervise the core room, taking out the work at night and preparing for the next day.

Is it any wonder then, in the face of this general description of duties, that the shop manager is unable, regardless of his good intentions, to give to the detailed steps of the various operations the close study which the securing of maximum efficiency demands? Brought up as I have been in the very atmosphere of the foundry, the point which has surprised me most, is not why a shop management fails to do better, but how it was able to do so well under the conditions which every shop man will recognize as the familiar daily routine.

We now come to the workmen. Even if it was considered as necessary, it would be impossible for a foreman to be with every man for the entire day. Consequently, barring the few general or detailed instructions that a workman gets from his foreman, the real responsibility for turning out a product of good quality in the quickest possible time is really up to the workman. Harassed as the foreman or superintendent usually is with the many details in connection with the daily grind, no other situation could be expected. It is also considered that because a man is hired as a molder and receives the regular rate of wage, he should know his business and therefore shoulder a large share of the responsibility. The molder comes to a plant as a man who

has been trained in other shops and because of this very fact his work may be made up of elements of weakness as well as of strength. He is expected to make work of good quality with not too much loss and in a reasonable time. If he can fill this general rather than specific requirement, he stays until he is dissatisfied. If he cannot, he is sent on his way for someone else to try out, which is both costly to the concern and discouraging to the workman.

The training of the men in any one shop is largely the result of doing the work as best they can plus observing what the others do, and the occasional word of advice and instruction from the busy and perhaps overworked foreman. *Our workers are not the product of a practical plan of intelligent direction and guidance.* An analysis of the records showing the details as to those who are hired, who quit, and who are discharged, will reveal a condition in many plants which cannot mean efficiency and which shows conclusively that we are failing to not only supply incentives but neglecting opportunities in man development. At any rate, the average man, as we find him, does not have the time, nor the training, nor the inclination to take the initiative in eliminating faulty conditions and doing everything possible in arranging for the proper adjustment of men and conditions. *If he did possess these essentials, he would be a foreman—not a workman.*

The Elements to be Considered.

Who then is going to give the proper amount of time and attention to

1. The determination and elimination of faulty and unnecessary motion made by the men;

2. The duplication by all men of the most efficient motions of the best men;

3. The scientific determination of the best that a man can do day in and day out without injury to his health;

4. The proper division of responsibility so that the men will not be asked to shoulder any beyond turning out a product of good quality, without delays and annoyances, in the shortest time possible;

5. The analysis and betterment of all faulty conditions;

6. Rewarding the men in proportion to the skill and effort of each man?

Variables of the Men and the Work.

The foundry industry is peculiarly one of motions. In a sense it is nothing but motions and in the estimation of the speaker *is one of the best fields there is to-day for the application of time and motion study.* Analysis reveals a number of variables both as regards the work and the men.

As to the work, there are:

Size of unit to be handled.	Position of worker.
Weight of unit to be handled.	Rapidity of motion.
Position of unit to be handled.	Exertion called for.
Method of handling.	Automaticity of motions.
Time consumed in making motions.	Facilities furnished.
Length of travel.	

As to the worker, there are the following, according to Gilbreth:

Brawn.	Fatigue.	Size.
Contentment.	Habits.	Skill.
Earning power.	Health.	Temperament.
Experience.	Mode of living.	Training.

I have repeatedly called attention to these variables in the worker:

Concentration.—Focusing the mind on one thing.

Reason.—Ability to draw conclusions.

Interest.—Exciting attention in a particular thing.

Judgment.—The faculty of reasoning logically.

Energy.—Strength and power exerted.

Imitation.—The inclination to follow the lead of another.

Imagination.—The faculty of forming images in the mind.

Attention.—Application of the mind to a particular thing.

Loyalty.—Faithful acceptance of a trust.

Memory.—Power of retaining and reproducing mental impressions.

Initiative.—The power of commencing something without guidance.

Pleasure in work.—The faculty of being satisfied with our work.

Necessity for Considering All Factors.

Considering the various classes of motions and the variables in the motions, as against the physical and mental variables of the worker, *it takes more than experience to determine the best attainable standards as to time.* A brief study will not do it for there are too many factors to consider, nor will an analysis of records showing what was done in the past serve as a basis for determining what is a fair day's work. I well remember a case where a molding time of nine hours for two men was set for a piece of work which had previously taken 27 hours for two men. The shop foreman was naturally indignant and the man who standardized the operation was looked upon as not knowing what he was talking about. The molders under the constructive measures introduced, which did not involve the purchase of new equipment nor a change in the method of molding, made the mold the first time in 11 hours, showing that the standard of 9 hours was within reason. It was simply a case of new methods of study and waste elimination against the usually accepted way.

Functions of Time Studies.

Studies are of two kinds: Time studies, in which time is analyzed; motion studies, in which motions are analyzed; and the use of both can be designated *timo* studied.

The functions of *timo* studies are:

1. Determination of an elimination of waste and inefficiency.
2. Standardization of: A. Conditions; B. Operations.
3. Improvement in the co-ordination of production details.
4. Setting tasks.
5. Basing rewards for individual efficiency.
6. Making estimates on work to be made.
7. Ascertaining costs in advance.

Tools Needed.

The tools needed in making *timo* studies are a decimal stop watch with an accumulating control at the side of the winding stem, a small hand counting machine and a clip board on which to place the sheets for entering the facts revealed by the studies.

Method of Making.

The method of making and using *timo* studies is in a general way as follows:

1. Resolve the work being studied into its various elements and movements.
2. Secure the elapsed time spent on each element from the stop watch.
3. List the particulars concerning each element, with the time spent on same, on sheets prepared for the time study.
4. Note on study all delays, useless motions, faulty conditions and whatever may be found in the way of inefficiency.
5. Note such delays and interruptions as are unavoidable.
6. Study for rest and fatigue of the worker.
7. Note the best element or set of motions on any kind of work for duplication in other lines.
8. Analyze the facts secured determining the amount of preventable waste in time and ascertaining the proportion of allowed working time to the total time.
9. From the data compiled standardize the operation as to sequence of elements and prescribe as far as possible the procedure as to the motions.
10. Set opposite each element or set of motions, an allowed time which will consider rest, fatigue and unavoidable delays.
11. Analyze the facts concerning waste and inefficiency and outline constructive measures to correct the faults found.
12. Index the data secured so as to file it with information of like nature.

Studies as to Classes.

Timo studies can be classified as follows:

1. General studies.
2. Operation studies.
3. Detailed studies.

The first would be used in cases where you wished to determine the exact molding time of a job. You would start the watch when the work was started, stop the watch for delays and irregularities, using the accumulating stem so as not to set the hand back to zero, and start again when work was resumed. Upon completion of the mold, the watch would show the net time spent in actually making the mold. This would not, however, give you any data as to the time taken by each step nor the wastes in any of the steps. Your readings would be about as follows:

First mold	85.5	minutes
Second mold	70.8	"
Third mold	62.6	"
Fourth mold	90.7	"
Fifth mold	50.9	"
Average	72.1	"

Second Class of Studies.

The second class of studies is much more valuable than the first because more information is obtainable. The work is to be divided into its various logical steps and each step listed on sheets along with the elapsed time for each. These studies can be made in two ways—by listing delays and faults as they are noticed or throwing out all such information and simply recording net actual working time. I prefer the former method for it is the analysis of such data that indicates the measures necessary to eliminate inefficiency. If the purpose of the study, however, is simply to standardize net working times, the inefficiencies can be eliminated in the readings. There are also three ways of using the watch in connection—snapping the hand back to zero after each reading or upon completion of each step stopping the watch with the accumulating stem, reading the time and then starting again, or reading the time after each step without stopping the hand. Personally I prefer the third plan, for in this way no time is lost in stopping and starting the watch. An operator soon learns to read a watch accurately without stopping it.

Your record would look something like this:

		Accumulated Time.	Net Time.
1.	Laying board and pattern	3.4	3.4
2.	Placing drag	5.4	2.0
*3.	Getting riddle from another workman	8.4	3.0
4.	Riddling sand	10.9	2.5
5.	Shoveling heap sand	16.1	5.2
6.	Ramming drag	36.7	20.6
7.	Placing bottom board	38.8	2.1
*8.	Looking for clamps	45.0	6.2
9.	Clamping and rolling	50.1	5.1
*10.	Waiting for cope side of pattern to be brought in	59.5	9.4
11.	Placing cope side of pattern	60.9	1.4
*12.	Waiting for cope	67.6	6.7
*13.	Waiting for carpenter to cut a bar	75.9	8.3
14.	Placing cope	78.0	2.1
*15.	Looking for gaggers	84.3	6.3
16.	Placing gaggers	88.5	4.2
17.	Ramming cope	100.9	12.4
*18.	Waiting for crane	115.9	15.0
19.	Lifting cope and placing	120.0	4.1
20.	Finishing mold	147.3	27.3
*21.	Waiting for cores	154.6	7.3
*22.	Filing cores	159.3	4.7
23.	Setting and securing cores	172.0	12.7
24.	Closing	179.1	7.1
25.	Clamping and weighting	187.4	8.3

Total time in minutes	187.4
Delays, etc	66.9
Net working time	120.5

By making a number of studies as indicated, considerable valuable information would be available for analysis, as will be appreciated by a persual of the elements listed. The study shows that delays 3, 8, 15 and 22 are due to faulty conditions, while 10, 12, 13 and 21 are due to improper planning. Delay 18 can in many cases be considered as unavoidable.

* Delays and wastes.

Further analysis would reveal additional information. Assume that the following readings had been recorded:

	A.	B.	C.	D.	E.	F.	G	H.	Avg.	Best.
Ramming drag.....	20.6	17.3	22.1	16.5	20.1	14.3	24.7	18.5	19.3	14.3
Ramming cope.....	12.4	8.4	14.2	7.1	12.9	10.4	8.5	7.6	10.2	7.1
Finishing..........	27.3	22.1	28.4	21.7	32.8	23.4	26.5	21.6	25.5	21.6
Setting cores.......	12.7	13.4	15.5	9.6	11.1	8.9	11.4	10.6	11.6	8.9
Total.........	73.0	61.2	80.2	54.9	76.9	57.0	71.1	58.3	66.6	51.9

The best time is 54.9 minutes at D. The average of all is 66.6 minutes. The best time is 51.9 minutes, and using the best average time as a standard, the efficiency is: 54.9, divided by 66.6, equals 83.9 per cent.

Using the best time as standard as against the average time and the efficiency is: 51.9, divided by 66.6, equals 78 per cent.

A fair standard would be:

Ramming drag........................	17.3 minutes from	B
Ramming cope.........................	8.4 " "	B
Finishing...............................	22.1 " "	B
Setting cores..........................	11.1 " "	F
Total..............................	58.9 "	

on which basis the efficiency is: 58.9, divided by 66.6, equals 89.9 per cent.

Determining a Fair Standard.

This naturally brings us the question—How is a fair standard determined, for it is obvious that the best time should not be used? No absolute law can be developed that will fit every case. The facts in the case plus careful study and good judgment are the governing considerations. It is possible, however, to arrive at an approximation in many cases, which will serve as a valuable indication of what standard to decide upon. In my practice I have used this rule—

A fair standard is approximately one-half the difference between the best time recorded and the average time of the readings, added to the best time or deducted from the average time.

You will note that the standard determined upon in the case just cited was 58.9 minutes. The average time was 66.6 minutes, while the best time was 51.9 minutes. The difference is 14.7 minutes, one-half of which added to the best time equals 59.2 minutes, or nearly the same as the standard of 58.9 minutes.

To carry it a step further, assume that four different operations have been studied six times each, with the following results:

	1.	2.	3.	4.	5.	6.	Avg.	Best
A......	20.1	18.7	16.4	24.9	14.3	17.1	18.6	14.3
B......	24.5	27.8	15.3	17.5	20.2	18.9	20.7	15.3
C......	35.2	30.4	37.5	26.4	31.5	29.5	31.7	26.4
D......	10.3	15.4	9.7	8.6	12.5	14.9	11.9	8.6

Standardizing the time without reference to rule or law and then adding one-half the difference between best and average time to the best time and the results would be:

	From figures without rule.	Using rule.	Difference.
A................	17.1 at 6	16.4	−.7
B................	18.9 " 6	18.0	−.9
C................	29.5 " 6	29.0	−.5
D................	9.7 " 3	10.2	+.5

In using this rule, it should be understood that it applies to standardized operations only and not to the time study as it is made. In other words, after making a study, eliminating delays, unnecessary motions and everything in the way of inefficiency, the several readings concerning a single operation, which as to method is now standardized, will show varying times, the average of which is to serve as the basis for comparison against the best time noted. To illustrate. The time study readings may be 56 minutes, the best average times of the standardized operation 28 and 40 minutes respectively. The rule would not be

$$.5(56-28)+28=42 \text{ minutes,}$$

but

$$.5(40-28)+28=34 \text{ minutes.}$$

Standardizing an Operation.

Let us standardize the operations from 1 to 25 previously discussed and determine the efficiency.

	Actual.	Standard.
1 and 2. Placing board, pattern and drag	5.4	4.7
4 and 5. Riddling and shoveling sand	7.7	6.0
6. Ramming drag	20.6	17.2
7 and 9. Placing board, clamping and rolling	7.2	6.1
11 and 14. Placing pattern and cope	3.5	2.0
16. Setting gaggers	4.2	2.5
17. Ramming cope	12.4	8.3
19 and 20. Lifting cope and finishing mold	31.4	24.5
23, 24 and 25. Setting cores, closing and clamping	28.1	22.7
Total	120.5	95.0
Delays	66.9	
Actual working time	187.4	
Time waiting for crane	15.0	
Net actual time	172.4	
Allowance		9.5
Total standard time		104.5

The efficiency, therefore, is: 104.5, divided by 172.4, equals 60.5 per cent.

Separation of Inefficiency.

Men and management are responsible for inefficiency, which in this case is 100, minus 60.5, equals 39.5 per cent, and because the delays which amount to 51.9 minutes are due to causes under the control of the management the net working time chargeable to the molder is 120.5 minutes, so that his efficiency is: 104.5, divided by 120.5, equals 81.7 per cent.

Consequently the inefficiency should be distributed as follows:

Man	16 minutes	23.6 per cent
Management	51.9 "	76.4 "
Total	67.9 "	100.0 "

You say I am too severe on the management—that the molder should assume some of the responsibility, to the extent at least of seeing to it that he has gaggers and clamps. I know from actual experience that the molder, in many shops, would have his hands full, if he had to see to it that he had what he wanted when he wanted it. Where will you draw the line? If he should look after gaggers and clamps why not expect him to get flasks, sand, patterns and other things? The molder should shoulder the responsibility for making good castings, in the shortest possible time and *nothing more*. The management should assume the responsibility for enabling the molder to work to the best advantage. Only through this clear cut division can the best results be secured. Whether you agree with me as to this, however, is not the question. The important point is that as shown the method of analysis described is a wonderful agency and can be used profitably in any campaign of betterment. We have by no means exhausted the possibilities, however, for there may be inherent defects in the operations which the second method of studying may fail to reveal. So far we have not considered motions to any extent. This is the function of the third class called "detailed" studies.

Detailed Studies.

To illustrate what I mean. Some time ago I studied the making of candy, which is of course quite different from making molds in a foundry, but the principles in both lines hold just the same. In watching the girls hand-dipping the centers I was surprised at the rapidity and the co-ordination of the motions which were made with such dexterity and swiftness that the eye could scarcely follow them, and I thought it was going to be by far the most difficult task of time study work I had encountered.

Close study soon revealed the fact, however, that the motions were divisible into certain classes, each class having its own peculiar motions. By starting the watch when the girl began the motion and stopping it by using the accumulating stem when she finished the motion, then waiting until she started the same motion again and starting the watch, I was able to get a time per 100 motions covering certain kinds of motions. I saw

too that there was a very definite relation between one motion and another, and by studying the performance of a number of girls separately to determine the peculiar methods followed by each, was able to arrive at some important conclusions. Some girls made 10 motions per piece, others 5. The average was 8.8 motions per piece. Standardizing showed that 7 motions were sufficient and that through proper direction and training 6 motions would do the work as efficiently as 8.8 motions. When I tell you that the girls averaged 83,000 motions per day of nine hours you will see how impossible it would have been to study the work in any other way. A study without analysis and the stop watch would have meant practically nothing.

Take "ramming" for instance. This involves three factors —number of motions, depth and time. Some molders will make many short, quick strokes while others will make fewer and slower but harder strokes. The time may be the same, but there may be a vast difference in the number of motions made. To study this operation it is necessary to measure the depth to ascertain whether one, two or more rammings are necessary. Measure the width and length for area. Start timing and counting the motions made, eliminating delays and interruptions, after which a factor can be determined showing number of rammings per cubic foot or per square foot for varying depths. After a number of studies have been made an average factor can be arrived at for different classes of work.

Setting gaggers is another example, for on the same work different molders will set a different number of gaggers and in varying times. The same kind of study will enable one to determine for different classes of work the number of gaggers to set and the time and motions involved.

Why go to all this trouble? There are three very good reasons why this virgin field, full of enormous possibilities, should be developed through motion study:

1. In any one shop some men are best at ramming, others most efficient at setting gaggers, still others best at finishing, setting cores, etc. Find the man who is best at any one thing. Study this thing and ascertain just how he does his work. Reduce it to standard practice and then induce the other men to

follow as closely as possible the standard way determined upon. Do this with as many of the details as will yield results and the gain will be surprising. All men following in all lines of work the best practice of the best men will mean more to the foundry industry than you have any idea of.

2. If a man as to time in ramming is 50 per cent efficient, and if the number of motions made are twice what they should be, the *efficiency of the man is not 50 per cent but 25 per cent due to the law of dependent sequence.* Assuming that a man has rammed a drag in two hours and without eliminating any unnecessary motions increases his efficiency to 100 per cent, it means that the ramming will be done in one hour. Now if properly directed he makes only one-half as many motions as he made before, he will ram the drag in one-half hour. The efficiency is therefore: 0.5 hour, divided by 2.0, equals 25 per cent.

3. These studies will reveal many things which are unnecessary. In slicking it will no doubt be found that some molders will use a small tool when a large one would mean much faster work. In nailing, I have many times seen molders placing nails much closer together than the requirements demanded. Cases have also been noticed where too much facing was used.

Making More Than One Study at a Time.

If the operator becomes skilful, two and even three studies can be made at one time with the same watch. The following will illustrate the plan:

	Man A.		Man B.	
Placing board and pattern..	2.5	2.5	7.8-10.4	2.6
Placing drag..............	4.5	2.0	13.0	2.6
Shoveling sand............	9.7	5.2	19.0	6.0
Ramming drag............	22.0	12.3	32.0	13.0
Rolling....................	24.0	2.0	34.2	2.2
Placing cope..............	27.1	3.1	37.0	2.8
Setting gaggers............	32.9	5.8	43.1	6.1
Ramming cope............	48.1	15.2	61.1	18.0
Total....................		48.1		53.3

$$61.1-7.8=53.3$$

Using Regular Watch with Stop Watch.

Studies can be made by listing the data pertaining to operations and eliminating all delays, or by listing delays and wastes noted and eliminating operation details. To get proper ratios, however, the starting and stopping time of observation should be noted from a regular watch using the stop watch for the time study. If, for instance, a study was begun at 9.15 and finished at 11.25 the elapsed time would be 2.10. If in this time you secured stop-watch readings covering the operation details amounting to 1.35, it would mean that there were delays amounting to 35 minutes, or 26.9 per cent, and the efficiency would be 95 minutes, divided by 130 minutes, equals 73 per cent.

Correcting for Errors.

It is sometimes convenient to study each element by stopping the watch, reading time, entering information on the sheets and at the same time snapping the hand back to zero for a new reading. When this is done slight errors will creep in and the regular watch should be used as just outlined. For instance, if the study consumed 320 minutes as shown by the regular watch and the stop-watch reading totals 305 minutes, the correcting factor is found as follows: 320, minus 305, divided by 305, equals 4.9 per cent.

Time Necessary to Make a Study.

Many wonder how long a time study should take. This is a difficult question to answer. When starting a study it is next to impossible to determine just what will be unearthed in the way of data and facts. A study may take an hour or it may take several days. It all depends upon the work, the degree of complication and where the points obtained lead to. It is a good deal like gold mining. The miner may dig for quite a time before he strikes an indication of gold. When he does, however, he follows the lead to where gold is in quantity. A safe rule to follow is:

"Take as much time to make a study as will result in sufficient facts on which to base conclusions which will withstand any attacks."

Rest and Fatigue.

No standard should be determined from a time study without considering the fatigue of the worker and the amount of rest required. If an ultimate attainment is 10 units in a day, it requires greater exertion per unit to go from 9 to 10 units than from 7 to 8 units. Counting normal effort 1, exertion for greater accomplishment is not 1, 2, 3, 4, 5, but rather 1, 2, 4, 8, 16. Yet men are oftentimes criticised for not attaining the 20 per cent from 80 per cent to 100 per cent efficiency as readily and as rapidly as the 20 per cent from 60 per cent to 80 per cent efficiency. The rule to follow is:

"Any standard determined should be one that a man can attain day in and day out without injury to his health of body and mind."

Let me give you a practical example of what I mean. Recently an operation was scheduled at 23 pieces per hour and the worker was for a reasonable period unable to make the schedule. It was decided to study the operation very carefully to determine why the standard could not be attained. The man working as he usually did produced 16 pieces per hour for 5 hours in the morning, or 69.5 per cent efficiency. Right after the noon hour I specified a 25-minute working period with 5 minutes rest, with the result that in the first hour 18 pieces were produced while in the second 20 pieces were produced. The time was then changed to 17 minutes work and 3 minutes rest, three such periods to the hour and the production rose to 22 pieces per hour. In the fourth hour, or the ninth hour after starting time in the morning, the division made was 10 minutes work and 2 minutes rest, and this resulted in 23 pieces per hour. The nature of the work was fatiguing, yet we were able to get 100 per cent efficiency at the end of the day by allowing $16\frac{2}{3}$ per cent rest. Subsequently the average efficiency of the man in question was between 95 and 100 per cent.

A blacksmith would want more rest than a molder, while the molder in turn needs more than a machinist. A man handling pig iron all day would need considerable rest. I often use a 54-minute hour as the working hour, which is equivalent to a rest of 10 per cent.

Speeding the Workers.

I am sometimes asked if the stop-watch time study is aimed to speed up and drive the men. If I felt for a moment that this was so I would in the future refuse to use one or have one used for me. In the hands of men *with their hearts in the right place* the time study is one of the most powerful agencies there is in bringing about greater efficiency.

There are three ways to make a time study:

1. By keeping the watch in the pocket so as to fool (?) the workman.

2. Going up to a man and without saying a word flash a watch and begin making notes.

3. Explaining to the men the purpose of the study; why the watch is necessary; what it all means; winning their consent and even their interest and approval and then making the study.

The first plan is the rankest kind of deceit and the man who uses this method should not be surprised if the men in turn try to "go him one better." He deserves it.

The second plan is disconcerting to the men; arouses their antagonism and makes them feel that they are mere puppets—to be observed without any right to protest or ascertain the purpose of the study. Only a man lacking tact and with no knowledge of human nature would attempt this sort of a study.

With the stop watch I have studied coal miners, molders, smiths, laborers, machinists, structural workers, and men and girls in other lines. I have yet to have my first difficulty because my plan has been:

1. Getting acquainted with the men.
2. Explaining the use of the time study and the stop watch.
3. Securing the confidence of the worker.
4. Explaining and discussing with the men the details of the work as the study progressed.

Practical Uses of Time Study Data.

One of the most important considerations in connection with time study work is the use to which the data can be put in standardizing the various operations. In discussing this phase I am going to anticipate your criticism, that while time study work

may no doubt be valuable in the foundry operating on repetitive work, it would not mean much to the specialty foundry owing to the large variety of castings to be made.

I am willing to admit that if a time study was made covering work that would not repeat for months the time study would mean little as regards the particular job. *In the information it would contain, however, lies its greatest strength.*

If you will stop to consider the elements which influence the making of molds, you will find that they are as follows:

A. The area of the mold.	D. The kind of molding.
B. The depth of the mold.	E. The pattern.
C. The class of molding.	F. The core work.

In order, therefore, to make time study data valuable in every foundry regardless of the class of work, the first step is to classify the various elements, as follows:

Class of Molding.

Green sand.	Bedded.
Dry sand.	Open sand.
Loam.	Chill.
Pit.	

Kind of Molding.

Hand.	*Machine.*
Bench.	Bench.
Light floor.	Light floor.
Medium floor.	Medium floor.
Heavy floor.	Heavy floor.

Pattern.

Construction.	*Kind.*
Simple—A.	Wood or metal.
Complicated—B.	Skeleton.
Extremely intricate—C.	Sweep.
	Core.

Shape.	*Mold.*
Regular—D.	Shallow—F.
Irregular—E.	Medium depth—G.
	Deep—H.

CORES.

Setting.	*Size.*
Simple to set—J.	Small—M.
Difficult to set—K.	Medium—N.
Extremely difficult to set—L.	Large—O.

You can readily see that no matter what conditions may arise the above classification is sufficient to cover the factors.

Let us first consider the more complicated operations made up of variables, which are:

1. Shoveling and ramming; 2. Setting gaggers; 3. Finishing; 4. Setting cores; and then consider each one separately.

SHOVELING AND RAMMING.

The rule to cover this would be:

C =cubical contents of flask.
C′=cubical contents of pattern.
F =Factor in hours per cubic foot of sand shoveled and rammed, for various classes of work, to be determined from time studies made.
T=Time for shoveling and ramming.
$T=(C-C'.) \times F.$

SETTING GAGGERS.

Two rules can be worked up to cover this operation. The first or simple one is:

B=Number of bars in cope.
L=Length of bar in feet.
F=Factor in hours per foot of bar from studies made.
T=Time for setting.
$T=2(B+1) \times L \times F.$

The more complicated but more accurate rule would be:

B = Number of bars in cope.
L = Length of bar in inches.
S = Spacing between gaggers in inches.
F = Factor in hours per 100 gaggers.
T = Time for setting gaggers.

$$T=\left(\frac{2(B+1)\times L}{S}\right)\times F.$$

Finishing.

This is an important part of the molding operations—an element in direct proportion to the degree of complication. Further, finishing is dependent upon the surface to be put into proper shape. Therefore, by using the number of square feet of surface as the basic unit and classifying the varying degrees of complication, a series of standards can be worked up from a wide range of time studies covering various classes of work, which when supplemented by such additional studies as may be necessary, will be approximately correct for all classes of work.

The elements to consider are: Construction of pattern; shape of pattern; depth of mold; and the combinations which can be used are as follows:

1. A D F	7. B D F	13. C D F
2. A D G	8. B D G	14. C D G
3. A D H	9. B D H	15. C D H
4. A E F	10. B E F	16. C E F
5. A E G	11. B E G	17. C E G
6. A E H	12. B E H	18. C E H

(Letters have been taken from standard classification.)

The following formula will cover the element of finishing, which is to include drawing the pattern:

S = Number of square feet of surface to be finished
F = Factor per square foot of surface covering the combination A D F, which, because it includes the simplest elements, can be considered standard.

A = Allowance in form of a percentage to be added to any combination differing from A D F.

T = Time for finishing.

$$(S \times F) + A = T.$$

Another formula can be worked up as follows:

S = Number of square feet of surface to be finished

F = Factor per square foot of surface corresponding to the degree of complication defined in list 1–18.

T = Time for finishing.

$$S \times F = T.$$

Setting and Securing Cores.

This element is dependent upon the number of cores, size of cores and the degree of complication in setting. A number of studies and a standard classification for different classes of work will mean a formula to cover this factor.

The combinations in this case are:

1. J M	4. K M	7. L M
2. J N	5. K N	8. L N
3. J O	6. K O	9. L O

The formula is:

H = Number of small cores.

H_1 = Number of medium cores.

H_2 = Number of large cores.

F = Factor in time per core corresponding to the combination defined at 1–9.

T = Time for cores.

$$\left.\begin{matrix} H \\ H_1 \\ H_2 \end{matrix}\right\} \times F = T.$$

Other Operations.

So far we have covered shoveling and ramming, setting gaggers, finishing and setting cores. The factors not covered are such operations as the following:

Placing board, pattern and drag.

Making joint.

Rolling.
Placing cope side of pattern and drag.
Lifting and placing cope.
Closing mold.
Making runners and heads.
Clamping and weighting.
Pouring and feeding.
Shaking out.

These operations are not made up of the same range of variables as the operations previously discussed. Time for any of the operations just listed will, of course, vary with the different classes of work, but the difference in time for any one class of work is not as a rule sufficient to warrant working up formulas for them. Consequently the plan to follow is to make a series of studies covering the various classes of work and adding these times to those determined by the use of the formulas.

It is now necessary in order to make the plan outlined of most value to foundrymen, to standardize the method of handling this information. As is necessary in machine shop and structural shop work, the foundry operations should first be analyzed. The combinations should then be worked up, the formulas applied and the times added for total standard time.

The sample sheet attached is a suggested method of handling. Places are provided for fully analyzing the work calculating and recapping the various times.

The course to pursue is to first make a number of studies, covering various kinds of work and then tabulate and classify the information. This will in a short time mean a considerable amount of valuable data which when considered class by class, will furnish the means for determining the proper factors for the various operations. Subsequently sufficient information will be gathered to cover all classes of work and the facts can well be termed the "standard practice" of the shop in question. Finally slide rules can be worked up to cover the practice decided upon and for an excellent description of this device, with reference to the foundry industry, I would call your attention to an article by Charles J. Simeon on the "Scientific Operation of the Foundry" in the January, 1912, issue of *The Foundry*.

ANALYSIS SHEET AND SCHEDULE
Smith, Brown & Co.

Schedule No.	Covering	Date

Description of Work—	
	Patt. No.
	B P No.
	Order No.

Class of Molding	
Green Sand	
Dry Sand	
Loam	
Pit	
Bedded	
Open Sand	
Chill	

Kind of Molding		
Hand	Bench	
	Light Floor	
	Medium Floor	
	Heavy Floor	
Machine	Bench	
	Light Floor	
	Medium Floor	
	Heavy Floor	

PATTERN

Construction		Kind	
Simple		Wood or Metal	
Complicated		Skeleton	
		Sweep	
Extremely Intricate		Core	

Shape		Depth	
Regular		Shallow	
		Medium	
Irregular		Deep	
No. to Gate		Ramming — Hand Pneumatic	

CORES

	Size			Setting			Time	
No.	Small	Medium	Large	Simple	Difficult	Ex. Dif.	Factor	Time
2								.3
1								.8
1								1.1
3								.5
								2.7

STANDARDIZATION

Shoveling and Ramming		Finishing	
Cubic Contents Flask	112	Sq. Feet Surface	70
" " Pattern	37	Factor per 100 Sq. Feet for ADF	1.5
" " Net	73	Time for ADF	1.05
Factor per 100 Cubic Feet	3.7	Allowance in % for BDG	45
Time in Hours	2.7	Time	1.5

Setting Gaggers		Study Nos. 270–821
No. of Bars	15	Schedule made by JLM
Length of Bars	4′	Approved by FBR
Total Length	60′	Date Effective 4–23–13
Factor per 100 Feet	1.16	Canceled
Time	.7	New Schedule No.

RECAPITULATION

Shoveling and Ramming	2	7
Setting Gaggers		7
Finishing	1	5
Cores	2	7
Placing Boards, Flask, etc.		3
Making Joint		5
Rolling		2
Lifting Cope		3
Closing Mold		6
Runners and Heads		4
Clamping and Weighting		7
Pouring and Feeding		6
Shaking Out		5
Allowance	1	2
Total Time for 2 Men	12	9

ORGANIZING THE WORK.

Just a word in closing to those who may be contemplating the introduction of time study work. Unless you intend to make the right kind of a study of the men; unless your aim is their betterment as regards both health and earnings; unless you have the right kind of men to make the studies—men who are tactful, diplomatic and who will wear well with the workers—it would be best to refrain from starting the campaign. If, however, you are with those wise executives who see in their men more than mere bone and muscle; who see a side awaiting development, secure the right kind of time study men and start the work. The results will surprise both you and the men.

It should be remembered, however, that the time studies will not in themselves correct all evils. There are other important requirements. The analysis of time study data will reveal faulty and wasteful conditions, imperfect and inefficient planning, unstandardized operations, and unless proper steps are taken to properly handle these elements, the time study campaign will fail to accomplish all that is possible. This, however, is not the fault of the time studies made but of the management for not properly co-ordinating the various steps.

You can readily appreciate how futile it would be after studying a job and finding that eight hours was sufficient time to do what had taken fifteen hours previously, to simply standardize the time and nothing else. This would be virtually putting it up to the men—the very thing we are trying to get away from.

Conditions should be made the best possible; the most efficient planning and dispatching arranged for; operations standardized as regards methods of working and times allowed. Time study data properly collected, compiled and analyzed will pave the way most efficiently for this work, and the only thing now remaining is to furnish the men with the incentive which will warrant them in taking full advantage of these improved conditions. I will not take the time to discuss wage payment methods, but I do want to impress upon you the fact that there is a law of wage payment which if lived up to will mean a surprising willingness on the part of the men to fully co-operate. This law is:

"Men at work will do their best and accomplish the most when engaged in work which stimulates; when rest balances exertion; when they can work efficiently rather than strenuously; when force and driving tactics give way to the leadership which attracts; when causes contributing to worry have been eliminated; when the attitude of "mental impossibility" no longer keeps them from attempting greater things; when responsibility is properly divided and the inefficiencies separated as between the management and the men; when provision is made to cover the natural inertia due to habit; when they have faith in the intention of the management to deal fairly and honestly; when they are guaranteed against cuts in rates; when they do not deem it necessary to hold back and become deceitful in their attempt to influence rates; when they are given an amount to cover the time employed plus an additional amount which represents to the men the skill and co-operation displayed."

CAST IRON SPECIFICATIONS AND INSPECTION.

BY R. S. MCPHERRAN, MILWAUKEE, WIS.

I am taking this opportunity to present before the American Foundrymen's Association a plea for more uniformity in making specifications for, and in the inspection of, iron castings. There are specifications written calling for test bars $1\frac{1}{4}$ ins. x 12 ins. round, 1 in. x 2 ins. x 24 ins., 1 in. x 1 in. x 12 ins., 1 in. x 1 in. x 4 ft. 6 ins., x 1 in. x 1 in. x 4 ft. 8 ins., etc. Sometimes the bars are to be corrected to some definite sized bar, and sometimes to some unfamiliar quality factor. Some specifications call for transverse bars only, some for tensile only, and some for both.

The minimum breaking load for 1 in. x 2 ins. x 24 ins. transverse bars varies from 1,700 to 2,500 lbs., and the tensile strength per square inch from 18,500 to 25,000 lbs. One specification calls for a tensile strength of 18,500 lbs. with an "allowable variation of five per cent either way." These different requirements on the part of engineers only serve to confuse the manufacturer. In the writer's opinion, much should be left to the judgment and experience of the latter.

In a shop where a certain kind of castings are a part of the regular output, the shop practice in making them is based on actual experience both in manufacture and in service. A purchaser calling for changes from this shop practice should do so only after careful consideration of the situation and for some definite reason. It is too often the case that a specification is copied from some handbook and inserted bodily in a contract without regard to the class of material it is to cover.

Specifications should be enforced with some consideration and evidence of good judgment. Reasonable latitude should be given the inspector in the interpretation of the specification clauses. Too severe a construction of a poorly written specifica-

tion often causes unnecessary loss to the manufacturer. In one case in the writer's experience the specification for suction piping called for a breaking load of 2,200 lbs. on a transverse bar 1 in. x 2 ins. x 24 ins. between supports. The same specification called for a tensile strength of 20,000 lbs. per square inch on bars cast to represent the steam cylinders. During the manufacture of this engine a set of transverse bars broke below 2,200 lbs. and caused the rejection of a suction pipe. The tensile bars from the same iron broke above 20,000 lbs. per square inch which would have passed a high pressure steam cylinder. We have here the anomaly of a material satisfactory for steam cylinders, but causing the rejection of a suction pipe.

The above is not to be taken as an argument against specifications or inspection, but only as an illustration of how both may be misapplied.

Some time ago this Association, working conjointly with the American Society for Testing Materials, adopted a set of specifications for Cast Iron and Iron Castings. You are all doubtless familiar with the "Arbitration Bar," so-called, which forms the basis of this set of specifications. The adoption of this bar ($1\frac{1}{4}$ ins. round, cast on end in dry sand, and tested transversely on supports 12 ins. apart) in this country has been very slow, owing to the prevalence of other bars in foundries, the information gained from which it is not desired to throw away. Nevertheless this $1\frac{1}{4}$ ins. diameter bar—though in different lengths—has now been adopted by most of the cast iron producing nations of the world. If there are any serious objections to its use here, these should be thrashed out and settled. But this or some other acceptable bar should appear in at least a majority of all the specifications used for gray iron castings. For want of anything better at the present time, I would urge the members of this Association to bring this bar into their specifications wherever possible, so that a good start toward uniform specifications may be made.

The result of a general adoption of the U. S. Navy bar as a standard for forgings has been so satisfactory that there is little doubt that better and more profitable results would follow the use of some standard cast iron test bar.

In this connection I would suggest that this Association discuss the status of the so-called "semi-steel." As we all know, the term is applied very loosely to all cast irons made with the addition of steel scrap in the cupola in any percentage. Should a grade of cast iron with a minimum cross-breaking load and tensile strength, in the making of which perhaps a minimum percentage of steel scrap has been used, be called by this title?

CORE TESTING AND STANDARDS.

By Henry Marquette Lane, Detroit, Mich.

For comparing binders or sands it is quite necessary to have some method of testing the strength of cores and comparing the same.

Foundrymen have been used to testing cast iron by the breaking of horizontal bars. For cast iron this is very good indeed, as the figures resulting are high enough to give a fair average, and errors due to irregular support are very small.

Several investigators have worked out a rule for comparison of transverse tests with tension tests for cast iron, and have found quite a different ratio between the two.

One advantage of the ordinary transverse test as used with inch square bars for cast iron is that the skin of the metal is not broken or removed before the test bars are broken. This results in stronger iron than we would have if the outer surface had been ground or planed off.

In cast iron the failure of the bar is always due to a crack starting from the bottom caused by the lower surface of the bar not being able to resist the tension existing along this side. In Fig. 1 we have a square bar *A* resting on supports *B* and *C*, and being broken by forcing a wedge-shaped point down on the center of the bar as shown on *D*. This places the lower edge of the bar in tension and causes a crack to start opposite the point *D* as indicated at *E*. From this we see that the failure in the transverse test is due to tension when dealing with material like cast iron which has a low tension test and a high crushing test.

The same thing is true in dealing with cores. For very strong oil sand mixtures bars 1 in. square and 14 ins. long and placed on supports 12 ins. apart can be broken by a hanging weight in the middle, and they will give very fair comparative results.

An experimental machine which was used in some of the tests is shown in Fig. 2. This consisted of two posts, the upper

ends of which were rounded to a ¼ in. radius, the bearing points or centers of these rounded surfaces being 12 ins. apart. At the center of the bar there was a yoke supported on a half inch bolt. To insure placing this central each time the gauge at the left was used. This was cut from a thin piece of hard wood and served simply to place the central yoke in its correct position. More elaborate supports were used on later machines.

Shot was at first poured into the pail, and later a device was arranged to flow it in automatically. By weighing the pail and the yoke the weight taken to break the core was easily ascertained.

A series of experiments were carried on some years ago in this connection by breaking 1 in. bars on supports 12 ins., 10 ins.,

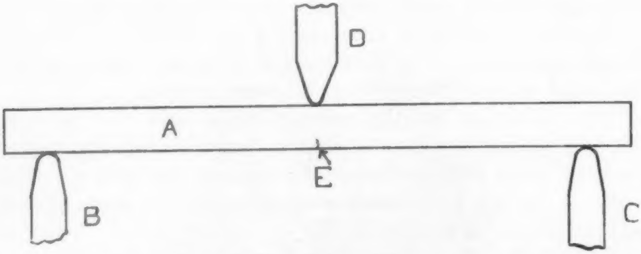


FIG. 1.—DIAGRAM SHOWING THE ACTION WHICH TAKES PLACE IN BREAKING CORES TRANSVERSELY.

8 ins., 6 ins. and 4 ins. apart. When they got down to the 4 in. supports it only left 2 ins. each side of the central piece *D*, and the results were not uniform. If a transverse test of this kind is to be used the best results seem to be with the 1 in. square bar broken on points 6 in. apart for ordinary core mixtures.

Another series of tests were run to break the samples in tension. In the first place, an ordinary concrete testing machine was tried, and for weak mixtures such as are used for many purposes this machine was not delicate enough. The cores for this work were made in a regular concrete mold as shown in Fig. 3.

A special testing machine was made as shown in Fig. 4, but this only had a capacity of 56 lbs., and many oil cores broke above this point.

A regular Fairbanks cement testing machine was used, but as already stated it was not delicate enough.

After this several machines for breaking cores in tension were developed, and finally the form shown in Fig. 5 was arrived at. This machine has since been put on the market by the Wadsworth Core Machine and Equipment Co., of Akron, Ohio.

The machine shown in Fig. 5 operates as follows: the core *A* is held between the wooden jaws *B* and *C*. A three to one lever is used for supporting the bucket *D*. A valve *E* controls the flow of shot from the hopper *F*. After the core is in place and the bucket hung from the lever, the valve stem *E* is raised, starting the shot flowing into the bucket. As soon as the core breaks, the bucket drops; the lower edge of the lever strikes the valve

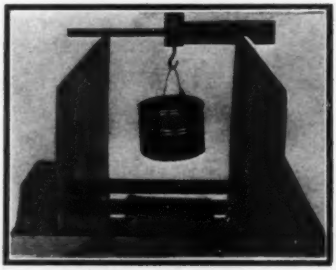


FIG. 2.—EXPERIMENTAL MACHINE FOR BREAKING CORES.

stem *E*, and automatically closes off the flow of the shot. The lever and link are balanced against the jaw *C* and its supporting mechanism, so that all that is necessary is to weigh the bucket *D* together with the shot it contains, and thus ascertain the weight which it took to break the core. The spring balance at the right serves to weigh the bucket. The weight of the bucket, of course, must be multiplied by three on account of the three to one lever.

In the making of cores it has been found that if the same man makes the cores regularly that they can be kept very uniform in strength. Different men, however, ram the cores to a different degree, so that there is usually some difference between the cores made by two operators.

With ordinary mixtures it takes from eight to ten times as heavy a load to break a core in tension as it would had the core been made one inch square, and tested on centers 12 ins. apart. From this it will be seen that small flaws which might make but a small difference in the transverse work would show a big difference in the tension work, and this enables us to throw out cores which are not perfect. Also it is much easier to make the small briquette shaped core for the tension test than it is to make a long core and have it perfect throughout its entire length.

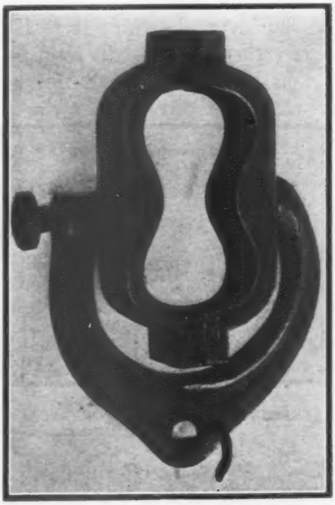


FIG. 3.—METAL MOLD FOR MAKING CEMENT BRIQUETTES OR TEST CORES.

The jaws for supporting the core have necessitated a good deal of careful study. Metal jaws such as are used in the ordinary cement testing machine have a tendency to crush the core and break it away from the center. Wooden jaws seem to give the best results, and for this reason hard wood has been used in the more recent machines.

Several attempts were made to develop a machine that would break a core 1 in. square, 12 ins. or 14 ins. long by breaking off pieces 2 or 3 ins. long from the end. The objection to this seemed

to be the impossibility of making the 1 in. core of equal strength throughout its entire length.

For ordinary shop control sample cores can be made from the ordinary mixtures and baked in the ordinary way. They will vary through quite wide ranges unless care is taken to see that they are baked the same length of time at the same temperature, but they will serve as a check for the work of the foundry.

For the comparison of binders or sands more careful standards must be used, and the material must be carefully mixed; the cores made in a uniform manner, and baked for a certain length of time at a standard temperature.

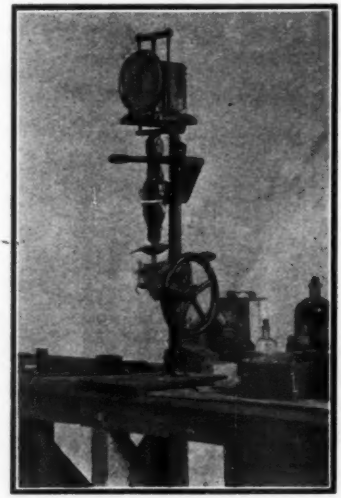


FIG. 4.—CORE TESTING MACHINE WITH AUTOMATIC REGISTERING DEVICE.

It is impossible to make a definite standard for all cases on account of the fact that the oven conditions in different shops vary radically, and if you are to test oil for a given plant you should naturally test under such conditions as to give the best results with the ovens in which the binder is to be used; hence, the temperature of the testing oven should correspond with the

average temperature of the regular ovens, and the tests should be conducted in accordance with shop conditions.

This does not mean that when a plant is being refitted it is not best to put in the most efficient ovens and to so control them as to get the maximum strength out of the binder.

As most of the foundries are now run the binder is fitted to the oven in place of the binder being fitted to the work, and this results in many foundrymen having to use from two to three times as much binder as would be required if they had different baking conditions.

FIG. 5.—CORE TESTING MACHINE HAVING A CAPACITY OF 225 LBS. PER. SQ. IN.

For the testing of oils some standard sand should be adopted, as, for instance, a good sample of a wind-driven sand like Michigan City, or a clean washed silica sand. The Government has already adopted through the Bureau of Standards the Ottawa silica sand as a standard for cement testing. A similar sand should be adopted for oil sand core work. For cores requiring a loam binder it would be well either to arrange for the mixing of a definite amount of standard clay with a pure silica sand or to adopt some standard sand containing a certain amount of clay.

The writer has never seen any sand banks which ran uniform throughout its entire area in its clay content, and for this reason

believes that a standard could be made up more satisfactorily by using a high grade clay, and a pure silica sand.

The result of the work thus far done seems to indicate that the tension test is far more accurate than the transverse test, and as this particular form is already a standard in the cement industry it is suggested that the Association adopt this as a standard core. A simple wooden core box is used for making these cores in place of the metal box.

It would be well to make a few tests before a standard sand is adopted, though for the comparison of oil sand it has been found that Michigan City sand or washed Ottawa silica are very good indeed.

This report is of necessity only a report of progress, and it is hoped that the next year's work will result in a more definite statement concerning standard specifications for testing core binders.

RECORDING MEMORANDA ON ACCIDENT PREVENTION.

By Thomas D. West, Cleveland, Ohio.

There are few occupations more hazardous and subject to accident through ignorance and error of judgment than the winning of metals from the earth and their conversion into articles of commerce. The risks incident to this, as well as every other activity, whether commercial, industrial, mining or the like, can often be greatly minimized or even averted altogether by conscientious effort on the part of the supervisors of the men engaged.

The author has tried in the following paper to give an insight into this phase of the *Accident Prevention* situation. In fact, this forms one of the thirty-five-odd chapters of a forthcoming work he is publishing on "Developing Overseers and Managing Men and Work."

Every person exercising a supervising influence upon men, while seeing that he receives a full day's work from them, should interest himself keenly in the prevention of accidents. Very little attention was paid to the subject six years ago, but owing to the recent universal agitation along this line, the present year, 1913, stands out as unexcelled in this respect.

In order to decrease the number of accidents materially, two factors must be taken into account. The first is that some accidents, or classes of accidents, could have been prevented by the simple exercise of judgment on the part of men who can reason. The other factor is the less patent one, as it has to do with happenings which cannot be foreseen. Thus, a wreck may occur on a railroad either as the result of an open switch or a broken rail. The first case falls within the range of readily preventable accidents, as the man throwing the switch should have reasoned properly. The latter case, however, could not have been foreseen ordinarily as things go. It may be stated that

for every one accident of the latter class, there are many of the first which are readily preventable.

Even the development of the multitude of safety devices, though doing much good along correct lines, has not reduced the accident percentages to any very notable extent, simply because the personal factor—the continually anticipating what would happen if certain conditions would prevail—has not been emphasized properly.

It seems unfortunate that our social and business fabric is such that credit is given the man who cures rather than the man who prevents accidents to life and damage to property. Nevertheless this should not deter us from doing our manifest duty as citizens and men in removing every factor that may lead to injury to or actual loss of life and property.

In the nature of things, it is the supervisor of things and men, or the manager of works, who should anticipate possible injury by providing guards of the right kind. He who is deficient in this will soon become obsolete in industrial life. There need only be called to mind the many accident compensation laws passed by the different states between 1911 and 1913. The day has passed when a person may be maimed and receive nothing in the way of compensation. It would need only a few accidents of the very highly paid kind to effectually put a firm out of business, even if covered by insurance, unless the resources were ample.

It is an idea of the author's, and which he has used in a limited way, that the supervisors of a plant should regularly make it a habit to jot down in a memorandum book any matter arising which might have led to an accident, and how this can be forestalled the next time. He has found this to work admirably, the cost is trifling, and need not be more than half a dollar a year per man acting as foreman, superintendent or manager. Either let the memoranda be jotted down during the day, or at home in the evening in thinking matters over. Doing this soon becomes as habit, and finally a satisfaction. If one can think "Well, I saved that poor fellow's finger today," or maybe his leg or life, or prevented a mistake which would have cost heaps of money, this must be a genuine gratification.

While the keeping of such a memorandum book of risks

annulled might be overdone by someone using it as a means of advancement for himself, yet employers of labor should foster the idea, and by showing a substantial appreciation, gradually encourage every one interested to do the same and thus enormously reduce accidents. Prevention is always better than cure.

It would indeed be well if regular blank forms were given to the supervisors of a plant with this purpose in view, as from the record of what occurred and what might have resulted therefrom will be learned the advisable safety devices a plant stands in need of specially. Moreover, this can be extended to include accidents of what might have been injurious to the property itself, and even the business.

He who has never given a thought to these things, on trying this memorandum record method, will be soon surprised to learn how much can be accomplished by it. He will soon see how many accidents and how much damage he can forestall in making his daily rounds about the shop and among the machinery. There will be many, of course, who will try this method and not find it help them much. This is a matter of individual disposition, and hence the system should not be condemned for failure when the real difficulty lies in the man who uses it.

The recent expansion of accident liability is quickly increasing the rate of those works in which the hazards are extra large on account of the indifference of the supervisors. It will eventually cause the rejection of many, or at least limit the compensation, amounting to extra premiums. It is quite evident that the original plan that every line of business shall have a rating to cover all chances of accident within it will not hold. It will happen that individual concerns will find their premiums advanced beyond others, even if in the same line of work, according to the prevalence of accidents they have and the character of these accidents. The ultimate effect will be the bankruptcy of those concerns not giving proper attention to accident prevention.

State liability laws are being closely watched as to their effect, and some results have come that have not been anticipated, to the discouragement of those who are anxiously seeking proper protection while desiring justice for their employees. There is a general interest displayed and the hope seems to prevail that everything will work out right and equitably.

Everything possible should be done by an establishment to hold its supervisors alive to the importance of preventing chances for accident, to adopt accident prevention and safety devices wherever possible, but not to depend upon these devices to the exclusion of the eternal vigilance required from every individual connected with the place. It is admitted that all this makes an extra load to carry, but humanity alone would require it, if indeed the selfish side of it did not make it obligatory at the present time.

THE NEED OF COMMON-SENSE COST SYSTEMS FOR THE FOUNDRY.

By E. W. Riker, New York City.

Introductory.—It was after considerable deliberation that the writer of this paper undertook to prepare an article upon foundry costs, for so much has been written relating to the subject by various individuals in their professional capacities or otherwise, and who are regarded as authorities on foundry affairs, that it is somewhat difficult to present anything very strikingly new upon the subject, or even bring to your attention anything relating to foundry practice that you, as foundrymen, have not considered many times over—not only from the point of view of accurate cost control for the foundry by economic methods, but from every other viewpoint that would help you improve the efficiency of your foundry. But, notwithstanding the subject is somewhat threadbare, it must be admitted that every foundry needs a cost system and needs it more today than ever before; it is positively necessary to foundry efficiency, economy and progress. The aim, however, should be to install a system that is not complicated or top-heavy, embodying a mass of detail with a large clerical force to operate, but a simple, plain and clear statement of current cost conditions, accurate and practical, and so valuable to the foundryman or manufacturer in the adminstration of his business and so satisfactory in the results therefrom that he never will regret the money he spent for its installation or the current cost of its execution.

During the past decade manufacturing operations in plants other than foundries have been very generally remodelled and in many instances completely changed by the introduction of modern methods, especially those relating to the cost of production; but the foundry has been neglected, or at least has not made comparable progress with other industries.

Foundrymen, as a group of industrial owners, are perhaps

the most difficult class of manufacturers to convince of the need of a cost system—and they hesitate the longest. This, perhaps, is not surprising when one considers the aversion which foundrymen generally have to the installation of any system of operation that involves detail or an interruption to the settled state of affairs with the fear of added cost of execution of the system in the way of clerical help. This, however, need not be the case if the system, whether it be a cost system or some other method of operation, is adjusted to the actual condition of the foundry in which it is installed and is therefore appropriate and really practical—not theoretical or modelled upon some basis that is not consistent with foundry practice.

One of the reasons why foundrymen are reluctant to install a cost system in their foundries is because of the failure of the system which they tried to secure for them cost results that are reliable and frequent enough to show the actual current cost conditions and aid them, as the system should, in securing greater foundry efficiency and economy.

The cost system of the future, whether for foundry or factory, will be one of more universal service than heretofore, will be looked upon with greater attention than ever before, be regarded as positively essential and unquestionably be more practically developed and used. It is one of the fundamentals of business existence. It is the chief instrument used to secure a high degree of efficiency through intelligent and economical management. It is the best known method to picture the conditions and progress of the business. The old methods of arriving at selling prices by guessing at the cost must be discarded. In this age of industrial progress, industrial owners cannot afford to ignore the subject of accurate costs and neglect to have figures showing exact cost conditions presented to them regularly and frequently.

The foundryman desiring to keep up to date must first install in his plant appropriate methods of administration, suitable methods of wage payment, accurate methods of stock control to prevent waste, and generally manage the affairs of his foundry along economical lines. The most valuable tool that he can use to assist him in this effort is the cost system—but, it must be accurate, it must be simple, it must be common-sense and economical in execution. It must be a systematic collection of

cost facts tabulated in such a manner that the foundry manager can quickly observe the running cost conditions for quick action to prevent abnormal cost increases. In many foundries, and other manufacturing plants, cumbersome and ineffective cost systems have been installed and cost results presented on more or less elaborate forms, but without due regard to the real substantial value of the figures to the administration of the business, and for this reason many men are in the industrial field who are not competent as professional advisers on matters of cost and other industrial accounting because they have not had sufficient experience in foundry practice to qualify them as foundry cost specialists and, too, because they do not fully realize that a foundry cost proposition is "different" and needs a special knowledge of the subject.

We hear a great deal nowadays of scientific management and how efficiency can best be secured by purely scientific methods; but these methods are apt to be ultra-refined and expensive to execute, especially when applied to foundry practice, and are not always advisable by any means. Rather let us consider the science of management as distinguished from scientific management which appeals strongly to a number of practical foundrymen and manufacturers and is a discrimination that permits a sane, sensible and orderly arrangement of affairs for the economical transaction of business, whether applied to a foundry, a factory, or other commercial enterprise.

Science is *systematized knowledge*, and in these days of business activity with competition growing more intense day by day it is necessary for executives to have all the *knowledge* practically and economically obtained relating to current operations of their businesses; the best way to secure this knowledge is through the operation of a dependable cost system that gives the executive control of his business.

A cost system is rightly called the mainspring of the business, but it must be practical; and when installed it ought to be clearly understood that such a system is not automatic and that its value depends largely on the understanding the chief executive of the business has of its principles and its possibilities. The foundry cost system that is right and fits the foundry into which it is installed should not require special accountants to operate it, but

just the ordinary foundry clerk who is practical by reason of his foundry education and experience and is therefore helpful to the foundry owner or executive because he will be practical and logical in his work and have his cost figures in such shape that they will give the exact facts when needed. This feature is mentioned here to convey to you the thought that if a foundry cost system is based upon the right principles and is appropriate to the foundry in which it is installed it can be operated economically. Therefore, accurate cost control of a foundry by economical methods is possible beyond the question of a doubt. A foundry cost system can readily be devised to fit the foundry for which it is intended that will absorb and account for every disbursement for material and labor, whether it is a direct or productive item or an indirect or non-productive charge. Furthermore, these disbursements may be separated to divisions or departments for efficiency in foundry management and still further be divided to classes of castings or to individual jobs or orders, to show complete cost of product by classes, by jobs, or by specific orders. All of this can just as well be tabulated and presented weekly, instead of monthly as is done in some foundries, and in a manner that is accurate, simple and economical.

The Cost System.—In order to secure exact costs the foundry is divided into departments which are the ones usually recognized, and which include, among others, the cupola, the core room, molding, cleaning and chipping, power and plant.

The cost of product should be obtained as a whole and by separation to classes, to jobs, or to specific orders, according to the individual foundry conditions. The results should be tabulated weekly and furthermore comparatively for prompt attention on the part of the management to developments that are abnormally high or appear to be irregular because they are too low. Provision should be made through the cost system for the accurate report and record of individual time of all employees in each of the divisions before mentioned and for the accurate report of consumption of material and supplies therein.

The non-productive or indirect expenses, differently known as foundry expenses, overhead charges, loading, or burden, include: superintendence, foundry clerks, shipping, yardmen, general laborers, cranemen, machinists, carpenters, blacksmiths, freight

and cartage, pattern repairs and renewals, tool repairs and renewals, bad castings, defective castings.

These expenses can be recorded through the medium of standing order numbers to which they are charged and distributed to the productive departments directly, where possible, or indirectly, in proportion to the productive labor in the several departments, and are also distributed to the classes of castings or individual orders as part of the costs. Finally they are tabulated to inform the superintendent or foreman in charge currently of variations in this class of disbursement for prompt action when any specific item or items show unusual increases. The power, heat, light and protection expenses are treated in a manner similar to the foundry expense disbursements and distributed proportionately and equitably to the productive departments and classes of product.

The fixed charges, such as fire insurance, indemnity insurance, depreciation and interest should be absorbed into the cost of product and appear on the weekly report separately for the reason that these items, being "fixed," cannot be increased or decreased by act of the foundry superintendent or foreman and therefore should not be merged with other items of foundry expenses which can be increased or decreased by the superintendent or foreman, according to the degree of efficiency he shows in the management of the foundry affairs.

Foundry betterments or permanent investments, such as real estate, buildings, machine tools, general tools, patterns, power transmission, piping, electrical equipment, etc., can be handled by the usual accounting methods applied to this class of property accounts, but the charges thereto should not be absorbed in current costs of product, only their upkeep and depreciation.

By means of the record of individual time and the segregation of this time to the several foundry departments or divisions, a complete check on payroll is obtained in addition to that which is secured through the medium of the ordinary time clocks. Likewise an accurate record of bad and defective castings is obtained for such attention as the superintendent or foreman should give to this ever present foundry expense.

The Cupola.—As foundrymen, you all recognize the necessity

for studying cupola processes in detail and will concede that at this point, if competent mechanical ability is applied as well as modern mechanical equipment used to save labor in the handling of material which goes into the cupola, the results will show favorably in cost reduction of cupola operation; at no point in the foundry is there greater need for the close observation of the official in charge of the foundry than at the cupola. The cost system starts at this point with the raw material.

A cupola report should be prepared showing grades of pig iron used, with quantity and value of each, and also quantity and value of machinery and foundry scrap, to ascertain accurately the total melt. From this are deducted the returns and bad castings, the result being the net cost of metal melted. To this is added the cost of fuel and supplies, such as coke, fire sand, fire clay, brick, limestone, etc., together with the labor engaged in the cupola division, the power consumed and the cost of repairs which are made from time to time for relining or other cupola repair work. Finally, a rate per pound of metal melted is obtained exactly and used later in the cost calculations. From the result of the melt and upon the cupola report the pounds of castings produced should be shown, separated to good and bad castings. The report should show further:

1. Percentage of good castings to gross melt.
2. Percentage of bad to total castings.
3. Percentage of returns to gross melt.
4. The melting loss.
5. The ratio of this loss to melt.

The report will be complete and include every item of cost of cupola operation reduced to a net cost per pound of metal melted from the cupola spout to the ladle ready to pour, for subsequent use in the cost of castings per pound by classes and in total or cost of castings by jobs or pieces. A cupola report is decidedly helpful also to the foundry superintendent or foreman in measuring the efficiency of this very important foundry department.

The Chemist and the Foundry.—It seems appropriate to refer at this point to the relation which the chemist has to the foundry, especially to the operation of the cupola and the really practical

part he plays in securing economical results. It is not intended, however, to refer to the subject with lengthy, well-known facts and stereotyped statements which fill the technical and trade journals of the day, but merely to call your attention to the basis upon which chemistry works in its service to modern foundry practice.

Through the science of chemistry, foundrymen are able to ascertain certain facts which cannot be obtained from any other source, and as chemistry is largely confined to the usefulness of the industrial arts it is not difficult to understand why the work of the chemist has become so closely interwoven with other good practices of modern manufacturing. The real utility of a chemist to a manufacturer depends upon his ability to lessen the cost of material used and, of course, to secure a product of desired quality; the owners of foundries are just beginning to wake up to the fact that chemists differ just as widely in degree of usefulness as do foundry foremen, lawyers, doctors or industrial engineers. Formerly it was the practice to "employ a chemist;" it is now becoming the practice to shop around a little until a chemist can be found who will not only earn his fee but whose work will also show a margin of profit to the concern employing him.

In the metallurgy of foundry practice there are many apparent contradictions; we often see two samples of metal having practically the same chemical analysis, but the two samples will possess different properties; the chemist who is properly qualified in the founding of metals must know a great deal more about the causes which bring about changes in the physical properties of metals than can be learned from the current literature of the day. By this we mean that all successful men in lines of effort have become well informed, skilled, and thorough through the thoughtful and studious execution of their duty in the field of practical work.

In the founders' art the successful chemist should be a practical melter and be able to hold the mixtures at the point of greatest economy for the product desired; he must be able to examine a defective product and point out the source of error therein and give intelligent and workable plans for avoiding its repetition. In the purchasing of material his services are valuable, for if he is a qualified chemist he will not confine himself

always to high grade material or approve of expensive specifications under which the seller must make shipments.

Foundrymen, however, must have in mind that unless the metal mixture determined by the foundry superintendent or foreman is closely followed and the weigher's returns accurate the efforts of the chemist will not be productive of as good results as will be the case if the man in charge of weighing in and charging the cupola is accurate in his reports. This, as you all appreciate, is essential and important.

The Core Room.—A report of the operations of the core room should be prepared showing the number of core-makers employed as a whole and separated to show the number engaged on the various classes of work; their hours to be indicated; the value of their labor and the value of the material used in the core room; which gives the total cost of core-room operations as a whole and by classes of work, reduced to rates per pound for each to show the cost per pound of core-room operations.

The Molding.—The report of the cost of molding should show the number of molders employed on the different kinds of molding—*i. e.*, dry, green sand, or loam work—and upon bench and machine molding. The hours of each molder should be indicated and the value of molding labor, as a whole and segregated to classes of work, to jobs, or to individual pieces; the value of the material used in molding should also be indicated as a whole and separated to classes, as in the case of the molding labor. Thus the total cost of molding as a whole and divided to classes or orders reduced to rates per pound for each is clearly and accurately obtained.

The Cleaning and Chipping.—A report upon the cleaning and chipping should include all labor and material upon all classes of castings and wherever possible should be charged direct to the kind of castings cleaned and chipped or distributed to the productive classes in proportion to the weight of product in each class. In any event, the entire cost must be equitably apportioned and absorbed to show the total cost of the cleaning and chipping division as a whole and by classes of work reduced, as in the case of the core room and molding, to rates per pound of product.

The Power and Plant.—The cost of power, heat, light, water and protection, which includes the engineers, firemen, watchmen,

gate keepers, electricians, and the cost of repairs to buildings, fixtures, tools, cranes, etc., with the general supplies, such as oils, waste, etc., that are used for this department, must be carefully recorded as used and separated from the other foundry expenses, not only for the purpose of ascertaining the exact cost of this particular division of the foundry but for the purpose of presenting to the superintendent or foreman current and correct costs of operation of the power and plant department.

The Foundry Expense.—The overhead expense or foundry loading, as it is frequently termed, is best indicated through the medium of the standing orders, and classified to the various kinds of foundry expense in sufficient detail to show the number of men engaged upon the different classes of foundry expense work, their hours employed, the value of their labor, together with the value of the expense material consumed to show a total of overhead expenses which must be absorbed in the cost of product of the foundry.

The Fixed Charges.—These charges which include taxes, insurance, depreciation, interest, etc., must be tabulated separately from the other foundry expense, shown on the weekly report, and absorbed into the cost of product currently by an accurate distribution on a basis that is fair and just and determined usually by the management.

The Summarized Results.—Finally, all of the foregoing information should be tabulated in a very complete form on a cost of castings sheet which shows the entire product in good castings, the cost of the metal melted, the cost of the core making, the molding, the cleaning and chipping, the power, heat, light, water and protection expenses, the general foundry expenses and the fixed charges, each and all distributed to classes of castings, and to foundry divisions to show costs per pound of each. Every disbursement, whether for labor or material—direct and indirect—is thus accounted for and capable of proof with the books of account.

Such a report should provide also for the entry of period costs—*i. e.*, accumulative costs from week to week, so that the last report prepared shows the accumulated period cost for any given number of preceding weeks. These summarized results tabulated in this manner on the cost of castings sheet can be

prepared from the reports which precede this one and in a manner that does not involve a serious amount of clerical labor. The cost of castings report gives to the superintendent or foreman cost information that is of inestimable value to assist him in his work of administration and his efforts to reduce costs of castings.

The Comparative Results.—An additional report in the nature of statistics may be prepared from the foregoing reports, arranged to show results comparatively by weeks as a further guide to the superintendent or foreman in his efforts to promote efficiency. Such a report exhibits the developments relating to good castings, bad castings, returns, total from melt, melting loss, total melt, average melt per day, defective castings, cost of metal melted, and also shows the ratio of foundry expense to productive labor, the average castings obtained per day—good and bad—per molder, and other useful data for the foundry superintendent or foreman to show just how these regular features of the foundry are running along and what variations develop. A further analysis of the product and of foundry disbursements may also be arranged comparatively to inform the official in charge of variations in these items. These statistical statements, while not actually a part of a weekly cost report, will be found very helpful to the foundry management in watching the trend of affairs.

The Weekly Reports.—One of the strongest and most effective features of a foundry cost system as outlined in this paper is the weekly report arrangement of cost data, for the reason that cost reports compiled so frequently give the superintendent or foreman in charge the opportunity to observe frequently irregular developments in costs of operation and thus furnish him with figures reflecting the actual cost conditions that will enable him to take prompt action to rectify any defects in foundry operations. For this reason, weekly reports are much more valuable to the foundry management than are those which are prepared only once a month when the data are history rather than news.

A weekly preparation may appear to involve an undue amount of clerical work, but this is not the case, for the foundry cost clerk should be assisted by suitable forms for gathering and recording data from the several departments which he needs for his weekly report, and as these data come to him daily in the current operation of the cost system he is enabled to classify much

of the information daily on analysis sheets, prepared for the purpose, thus assembling the figures needed for his weekly report each day to further enable him to compile his report at the end of the week promptly and without serious effort.

It is not a difficult matter to ascertain accurately and currently the amounts expended for direct labor and material—indeed, this is quite simple, but just how to ascertain the overhead and apportion it equitably and accurately and to be sure that all overhead expense or loading is absorbed in the cost of product requires careful study and a knowledge of the subject obtained from years of actual practical experience. The problem, however, may be positively solved in the system herein outlined and the subject handled in such a manner that not only can all of the foundry disbursements be accurately and positively absorbed, but presented to the management in such a manner that they may take immediate action intelligently to correct and adjust any matters that are not right.

The Stores and Stock Control.—In connection with a foundry cost system and auxiliary to it, a system of stock control should be operated and can be in a very simple manner, not only to regulate purchases of material and foundry supplies and to properly govern their use, but, through the stores system, assist in eliminating waste of material, reduce the working stock and thereby reduce the capital invested in this class of property. A stores and stock system further provides a current inventory and effectually prevents careless and indifferent buying, overstocking, and furnishes a means of inspection of this class of property that is most desirable and very helpful in the effort to economize in foundry material and supplies. Through the stores system every item of material and foundry supplies that is consumed in the foundry is under stores and stock control and accurately accounted for.

A stores and stock record is but another term for "stock ledger" with the receipts and deliveries expressed in quantities and value. Stock on hand represents money; perhaps not quite as quick an asset as a bank balance but, when purchased and stored without a well-defined stores and stock system of control, overstocking is liable to occur, is a bad investment, and becomes eventually perhaps dead stock. No matter how careful the foun-

dry superintendent or foreman may be in his supervision of this asset, unless a complete and accurate controlling record is in operation, waste, loss, misuse of stock and extravagances repeatedly occur without detection. Furthermore, ordering stock on impression rather than on actual record of consumption, no matter how intelligently done, can but result in inadequate provision. Purchases under such conditions are usually matters of guesswork. The purpose of a stores and stock control is to eliminate guesswork and provide a method of operation relating to this class of property that will remove uncertainties in connection with quantities required and "speak by the book" in every instance. A stores and stock system, therefore, needs no argument as an economical feature of efficient foundry administration. The cost of placing all material and supplies under individual control is nominal and the cost of disbursing upon requisition is paid for many times over during the course of a year in the savings effected by stores and stock concentration and the special supervision given this class of property and which the system should embrace.

Conclusion.—It is safe to declare that a large number—indeed, a large majority—of industrial owners and manufacturers do not fully comprehend what a complete and exact cost system really means to their industries and that such a system is positively essential to permanent and increasing business prosperity. It is, of course, necessary to have a well defined and appropriate organization, efficient management, adequate equipment and capable workmen, but above all these, the need for a reliable cost system stands out very prominently.

For the foundry, the cost system must be just as exact as in any other industry but need not go into the detail that is often advisable in other lines of manufacture. Hence, in presenting this outline of what the writer considers a "Common-Sense Cost System for the Foundry" it is hoped the foundrymen present will understand that in no sense does this paper recommend the installation of a cost system in any foundry that is not simple and common sense in its every feature. Two points in connection with the installation of a cost system—whether in a foundry or a factory—must be clearly understood; namely, it takes time and perseverance. Various elements must be reckoned with and

various obstacles overcome; and above all, to make any good system a success and secure from it the results which it should produce, it must have substantial and continuous support of the chief executive of the business. In other words, if the foundryman concludes that he wants to install a cost system and lets it become known to all employed in his foundry that such a system is to be installed and operated and is to have his complete and active support, a large part of the work of the foundry cost specialist and the task of installation is accomplished and his efforts to devise, install and instruct are materially lessened; whereas, if a foundryman concludes that he would like to have a cost system installed and falters a bit in his belief or faith in its results, and if he does his attitude will be quickly observed by all the employees, the work of installation will be more difficult and the obstacles harder to overcome than if positive support on the part of the executive is given at the outset.

A great deal depends upon the cost system adopted. Its elements or principles must be thoroughly understood; they must be treated separately and collectively and absorb all items of cost, direct and indirect. In these days of business progress it is extremely hazardous to any business to use cost figures that do not represent the total expenditures for labor, for material and for expense, and which cannot be proved. If cost figures are used that do not include or absorb these three chief elements of cost, selling prices are apt to be made that will not show a satisfactory profit, if any, when the fiscal year's balance sheet is prepared.

The three factors referred to which enter into the cost of each and every article of manufacture—whether it be a casting or a machine tool or any other manufactured article—may and do vary in dimension, but all three are invariably present and a "cost" which omits any one of them is incomplete and deceptive. The established principles of manufacturing costs are recognized by qualified industrial engineers and accountants and must be carefully applied if the figures derived from the cost system are to be of any use whatever. No business can be operated successfully, permanently, without a correct knowledge of the cost of its product and these costs cannot be obtained without a clear conception and application of the fundamental and established

principles of cost accounting. If all the foundries in the country were operating under a uniform common-sense foundry cost system the foundry industry would be benefited more than any of us can possibly realize until we actually observe the excellent results of such uniformity.

Let us remember the real function of a cost system is not merely to record the cost of operation but to assemble data that can be used with a clear and correct understanding to reduce costs; then it performs its duty and becomes the most valuable agent known to promote foundry and factory efficiency. The logical conclusion, therefore, is that every foundry and every industrial plant needs a reliable cost system to present in an orderly manner regularly the facts relating to the business clearly and to tell the story, week by week, of the actual current business conditions with exact costs of operations by divisions and departments of the business. What a great forward step would be taken in the science of industrial accounting, especially that branch of it which concerns costs of product, if each different class of industry would adopt uniform methods of cost calculation.

An authority on manufacturing costs in a recent paper upon the subject very aptly says:

"The aim and object of every cost system should be to afford true and accurate information as to facts. It is based on facts; it should embody and present facts and naught else. To exaggerate facts and to show fictitious profits and values is no worse than to depreciate facts and to conceal true profits and values. Accounting in its application to general business affairs has long been a highly developed science, but is comparatively a new one in its specialized application to modern industry, with its vast and complex development. The creation of a *Correct Science of Industrial Accounting* and costs should be the desire and aim of all who are concerned with industrial management. To accomplish this, three things at least are needed:

"(*a*) Clear understanding of fundamental principles.

"(*b*) Definite terminology generally understood and accepted.

"(*c*) Frequent interchange of the data of practice, whereby the adoption of sound principles may be promoted, the experience

of each may be available to all, the best methods may become established, and above all, a standard system may ultimately be created.

"The accomplishment of these results, by affording complete and accurate knowledge of the facts pertaining to industrial efficiency, and to the costs of production, will tend greatly and permanently to promote the development of American industry and to aid it in securing its full share of the markets of the world."

While the above quotation applies more especially to manufacturing industries other than foundries, its appropriateness to the foundry cost problem will be acknowledged and substantiate the statement previously made in this paper that a uniform foundry cost system, standard in its scope, designed along the simple and common-sense lines suggested herein, is as much needed by the foundries of the country today as anything in which they are interested. Nothing will aid the foundry more than to secure from a cost system just what it is expected to furnish.

SOME DIFFICULTIES IN POURING STEEL CASTINGS.

By R. A. Bull, Granite City, Ill.

If there is one cause more than another which is periodically productive of the maximum annoyance to the man operating the steel foundry, and which gives trouble with less apparent reason for it at times, it is a leaking ladle. The writer has the frankness to introduce his subject with the admission that liquid steel deposited where it was not intended to go has many times disturbed his peace of mind. To others of his kind—and there are many such—he invites, for mutual benefit, a discussion of the factors pertinent to the topic, while offering a few suggestions experience has shown to be worth while.

Beginning first with the ladle as a unit and the necessity for keeping it suspended from the trolley—and this point will not be lost upon those who have seen a ladle of steel drop to the foundry floor—it is a most unsafe practice to use chains for the ladle crane. Wire rope has superseded the chain on the drums of most of the modern pouring trolleys, but not on all. The reason for the use of the rope is obvious. Many a poorly welded link shows no surface defect, while a wire rope gives warning of excessive wear and weakness by the parting of the outside strands. In these days of proper regard for the safety of employees the use of chain in carrying a steel ladle is on a par with the use of cast iron in the construction of the trolley itself, and is simply inviting catastrophe.

Coming to the ladle bail, it is superfluous perhaps to say that it should be forged of the best possible material, and designed with a high safety factor. But more than that, it should be jointed so as to relieve undue strains caused by sudden or unexpected movements of the crane bridge or trolley. A stiff sling hooked over the ladle trunnion, rigidly attached to the cross-arm, is not conducive to the flexibility which is sometimes very desirable

and which undoubtedly prolongs the safe life of the bail. The cross-arm should be provided with a shield to protect it somewhat from the heat underneath, and there should be an air space between shield and cross-arm. It is a good plan yearly to anneal the entire bail as well as the cranehook, to prevent crystallization.

In making up the stopper-rod, great care should be taken in the use of keys for securing the stopper-head. It is false economy to use a key more than once. A crystallized key may cause a heavy loss and the cost of a new one is negligible. The joints between the sleeves of the stopper-rod, as well as those between the bricks of the ladle lining itself, should be carefully looked after for reasons not necessary to state. Sleeves, stopper-head and nozzle should be selected with great care, to see that none are cracked or patched, and that the contour of the nozzle enables the stopper-head to have a perfect seat. The black ring left by rubbing a graphite stopper-head around a clay nozzle is proof of fit.

Having made up the rod, of course the clay joints should be well dried, like the clay lining of the ladle bricks. And in drying the ladle itself many believe an upright position to be preferable. Undoubtedly the brick lining is thus less susceptible to displacement. Perfect lining would sometimes prevent those red spots which suddenly appear on the ladle plates, which are immediately followed by the melting of the latter and a very awkward breaking out of the metal. The nozzle must be carefully set and well rammed in, and the lower portion should extend below the nozzle-plate sufficiently to enable the metal to clear the plate nicely and not become "gummed" at the outlet.

The setting of the stopper-rod calls for nice adjustment under somewhat unpleasant conditions, and for this a careful, painstaking man is essential. This work I believe can best be done under the direction of the melter so there can be no division of responsibility. The mysteries of ladle-leaks, and consequent difficulty in fixing responsibility for bad spills, are quite sufficient at best without adding to the difficulties by inviting controversies, which sometimes prevent unbiased analysis of causes.

In tapping the heat, the additions should be of moderate size to enable reasonably quick melting and thorough distribution. Large lumps of ferro-manganese, gravitating to the nozzle, may

stick to the lip of the latter in a half melted condition, and cause a very bad shut-off. The melter should personally look after the size of the lumps constituting the additions, and the introduction of these into the ladle, which should be regulated by the nature of the tap.

Given a perfect heat and a perfect ladle, there should of course be a clean shut-off. But this is by no means always the case. The ladle-man or steel-pourer may inadvertently open up too strongly on his first flask. Then if this initial mold is moderately small so as to fill quickly, the man whose hand operates the lever may have hot work cut out for him for a period. The steel pouring over the lip of the nozzle without any check from adjacent position of the stopper-head may seem determined to flow regardless of the movement of the lever. This is due to chilled steel adhering to the nozzle, preventing a perfect seat, and caused by a tempestuous flow of hot metal in excessive quantity over a comparatively cold nozzle. A restricted flow, giving time for such a "skull" to melt away if it forms, is highly desirable on the first mold. Sometimes the stopper-head may stick to the nozzle at the start and excessive pressure must be exerted on the lever with the result that the stream may open in greater volume than intended, through the sudden release.

Occasionally through careless manipulation of the lever, a very small amount of steel may trickle from the nozzle, which in itself may be of no consequence. This must be very closely guarded against by pinching the stopper-head tightly at all times against the nozzle. An apparently insignificant dribble is very likely to cut the nozzle and produce a nasty leak. Once the nozzle begins to cut away, the teeming of the balance of the metal should be expedited with all possible dispatch by pouring the nearest and largest molds, for almost invariably the stream will soon become so large in area that the pouring cups will not accommodate it.

Sometimes the stopper-head or the nozzle, or both, will wear away considerably during the pour, consequently increasing the height of the lever, and preventing the ladle-man from handling it with skill. This may itself cause the steel to trickle, with the bad possibilities before mentioned. An adjustable lever to meet such contingencies is far better than a hastily moved

temporary platform on which to stand or a vertical addition to the end of the lever by means of a molder's shovel.

A prolific source of leaks is cold metal, which encourages the formation of skulls around the top of the nozzle. This cause is of course one easily determined and may give very serious trouble during the early pouring. On the other hand, I have heard some foundrymen attribute bad leaks to the temperature of the steel being too hot. I have never felt satisfied with such an explanation, believing that the temperatures attained in the open-hearth furnace in regular practice are not sufficient to cause a leaky stopper, given a perfect ladle, with all that implies. Unquestionably the impact of the stopper-head on the nozzle, with both in a highly heated state, will make them wear down. But if they are of good material and perfectly sound, such wear, as I believe, will be uniform.

I have seen leaks which experienced foundrymen have insisted were caused by the slag freezing on the top of the metal and binding the upper part of the stopper-rod. I recall some of these where there was no possibility of definitely determining the cause, and where perfectly clean shut-offs were experienced at the start. Suddenly the lever would refuse to budge, without anything being jammed on the outside of the ladle, and finally come to the desired position, shutting off the stream after considerable metal had been lost. Obviously something had interfered with the operation of some part of the stopper-rod, but I believe slag to be too fragile to resist the force applied to the lever. What produced the trouble could only be surmised.

I have not by any means enumerated all of the troubles experienced in pouring steel. Many of us have seen stopper-rods burn in two, stopper-heads burn off, and stoppers stick so tightly to nozzles that "prickers" had to be resorted to to open them. It may be mentioned in passing that wooden prickers are to be preferred, as they will not fuse to the semiplastic metal sometimes present in the nozzle orifice. An ordinary gate-stick is always available and will generally force an opening.

I have not mentioned the skill requisite in pouring a perfect heat from a perfect ladle, to guarantee the best possible results in the castings. This is a very important matter, and if not given the needed attention may throw the blame for mis-run and

cracked castings on the shoulders of the melter unjustly. A knowledge of the design of the mold itself, the manner in which it is gated, the approximate weight of the casting, have a direct bearing upon the proper control of the stream. Insufficient feeding of heavy sections is not only productive of shrinkage cavities but also, according to my observation, of shrinkage cracks, when the cavities may not be in evidence. A large number of risers of moderate size enables better feeding than does a small number of very heavy sink-heads. But however these may be designed or placed, the ladle-man should hold his ladle over the mold till the risers are solidified past all hope of further feeding. Naturally a leaky stopper presents complications in so doing.

The difficulties herein mentioned are only a few of those that attend the transfer of steel from furnace to mold. It may be admitted that today bottom-pouring in general is a very neat mechanical manipulation. Nevertheless, all of us have an occasional bad heat to handle and need others' experience to draw from as well as our own. But despite all the help available from his colleagues, the steel founder must by his own experience work out many ladle problems for himself, and should constantly study the art of pouring, realizing in direct proportion as he does this, its very great importance.

THE INDUCTION FURNACE AND ITS USE IN THE MANUFACTURE OF STEEL.

By Albert Hiorth, Christiania, Norway.

The use of the electric furnace for the production of high grade steel is now so well known, and its value so generally recognized, that the producer of steel castings is turning his attention to this method of operation more and more. Any method that will give molten steel with the greatest freedom from oxidation, entrained slag, and also with a minimum of impurities, quiet and exceedingly hot, is certain to find application, cost what it may. If, in addition, through increased efficiency in the mechanical portion of the plant that is necessary, a reduction in operating cost is attained, so that today it is possible to supply the exacting demands of an appreciable percentage of consumers of steel castings in competition with open-hearth material, it will pay every steel founder to watch the electric furnace situation closely.

The tendency of the times is toward better material. A pound of iron has to go further than formerly. To do this it is necessary to increase the quality to a point where either a higher elastic limit is attained or else the factor of safety can be lowered without fear of failure.

In the selection of the electric furnace for the steel foundry, there is room for argument. Whether the arc or induction furnace is best, that which is fittest will survive. In the following memoranda, the author describes his own furnace and gives data which he trusts will be of interest to his American co-workers in the advancement of the art of making high grade steel castings.

The description given herewith is taken from a paper by Prof. Joseph W. Richards, read before the American Electrochemical Society (October, 1910) as the result of his personal inspection of the furnace in Norway in 1910.

"The Hiorth electric furnace is a double-channel induction

furnace, with the primary consisting of four coils connected in series. Fig. 1 shows diagrammatically the electrical principles, *E* being the steel bath, with its two channels *dd*, *a* the magnetic circuit, *bb* the upper coils, co-extensive with the heating channels, and *cc* the lower coils. The coils *bb* are suspended from pulleys with flexible connections, and when running, are close against the covers of the channels *dd*, but can be raised about 60 cm. (24 ins.) when the covers are to be removed. The coils *bb* are un-

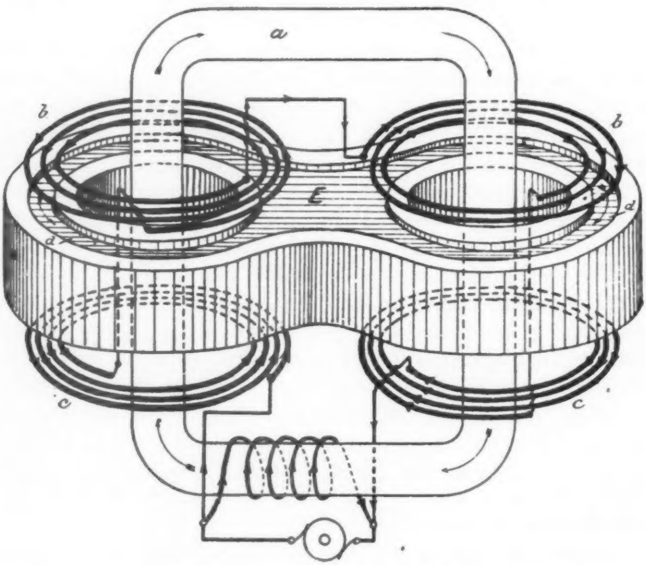
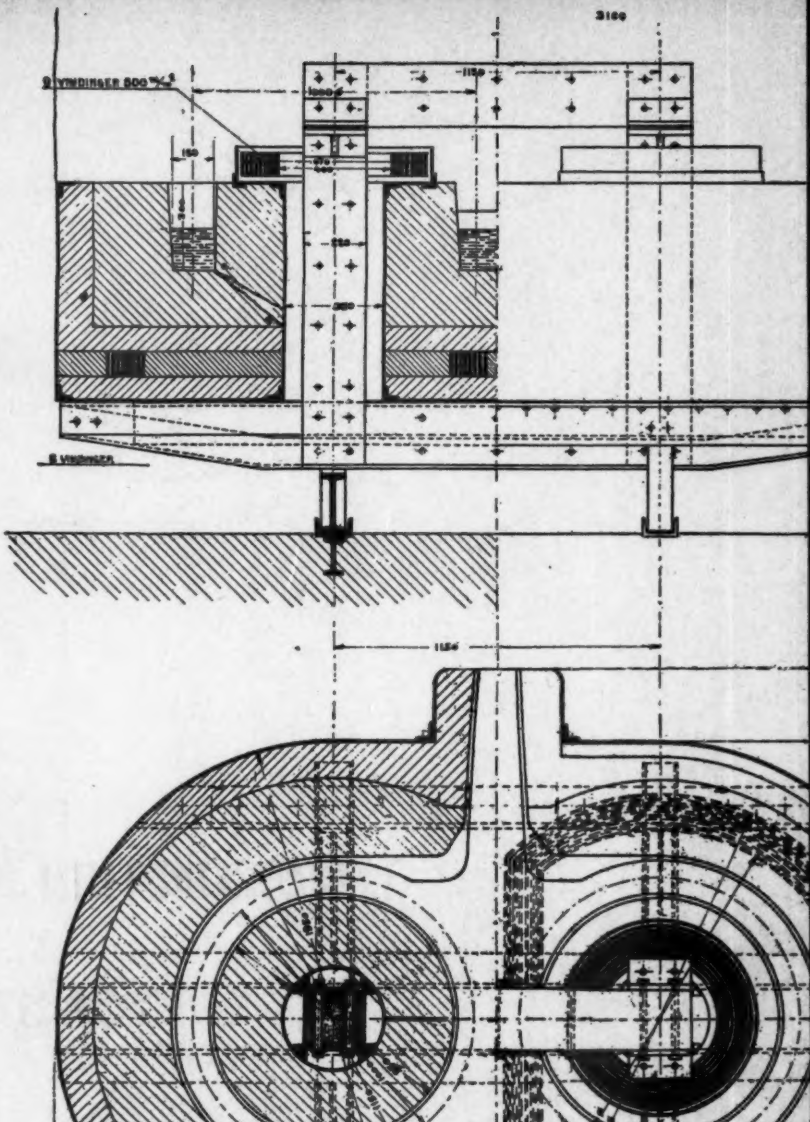


FIG. 1.—HIORTH FURNACE: DIAGRAM OF ELECTRIC CIRCUITS.

insulated, bare copper bars, coiled spirally. The coils *cc* are hollow, water-cooled copper conductors, and in the actual furnace are embedded in the magnesite lining about 40 cm. (16 ins.) beneath the channels *dd*. The voltage employed on the primary is so low that no particular precautions for insulation are needed, and no one can be seriously hurt by it. The space between the magnet *a* and the furnace wall is a clear 30 cm. (12 ins.), which allows of the magnets (which weigh several tons) being bolted,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1150
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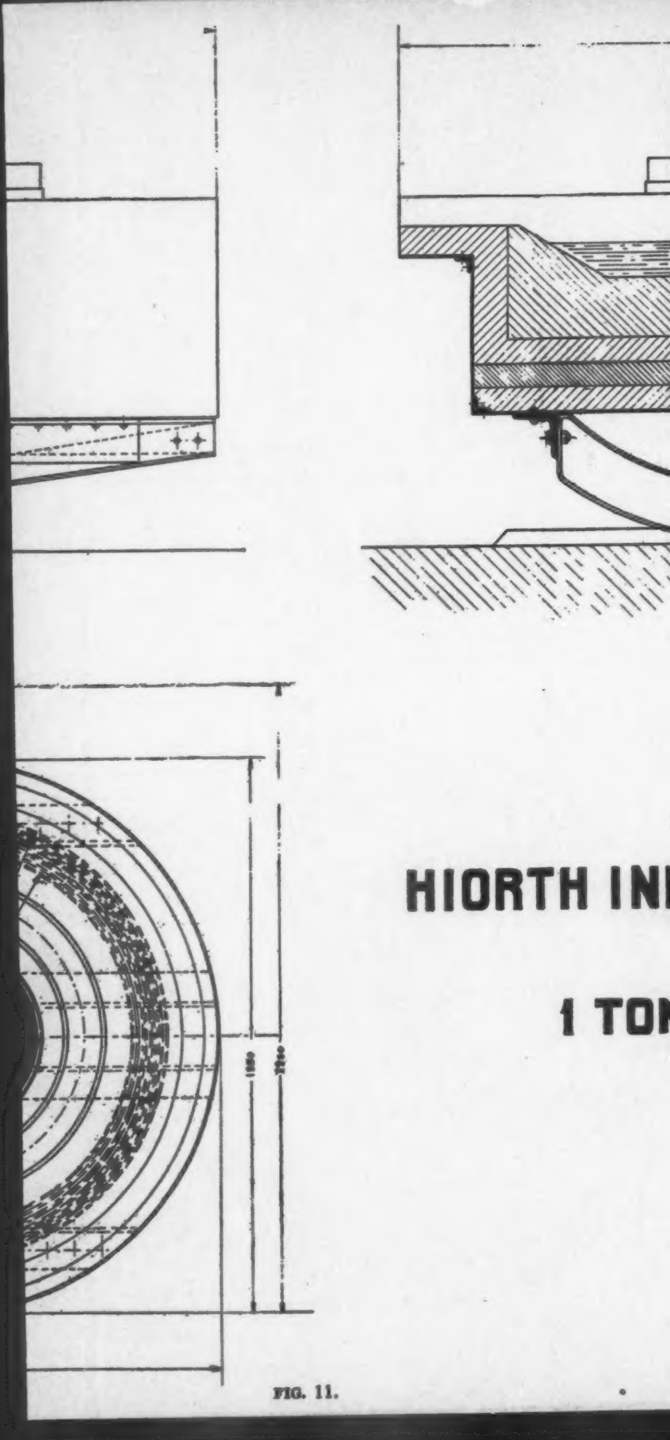
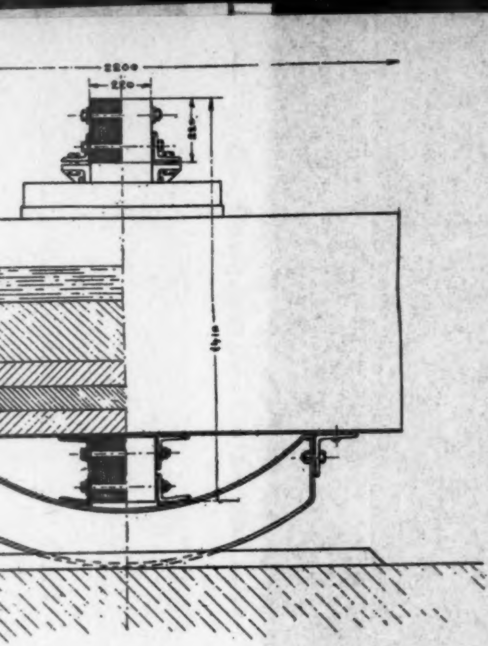


FIG. 11.



NDUCTION FURNACE

ONS CAPACITY

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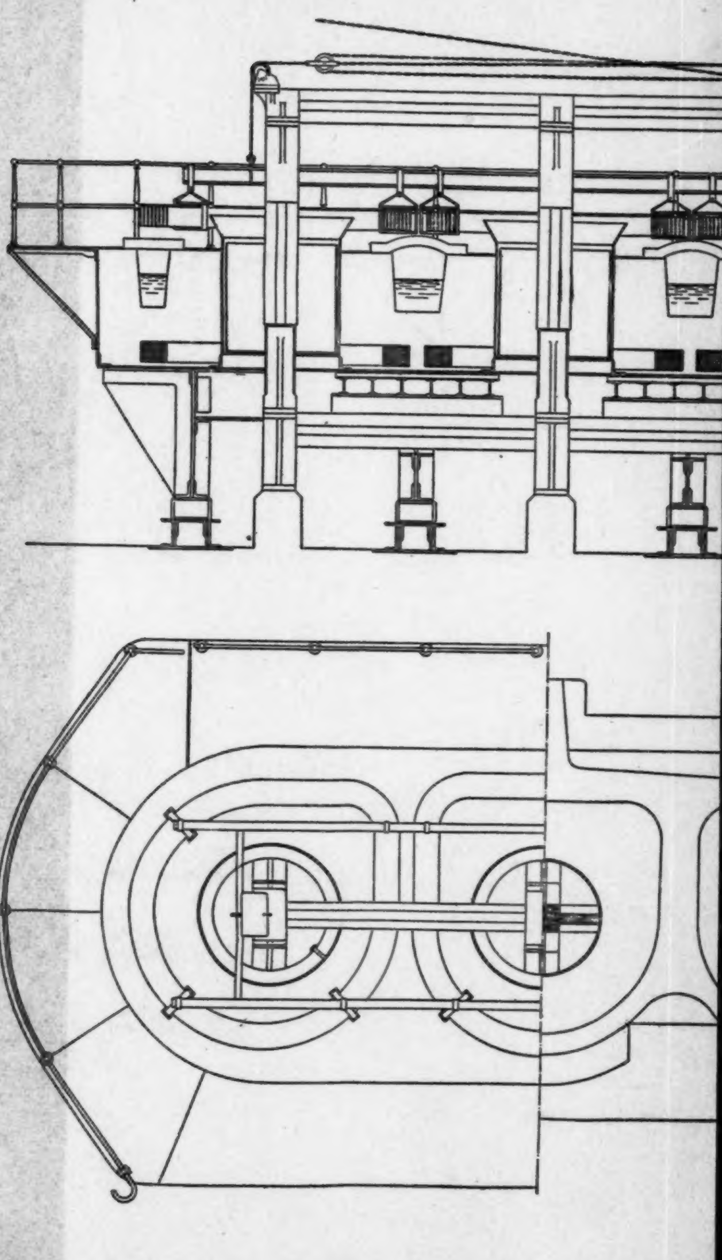
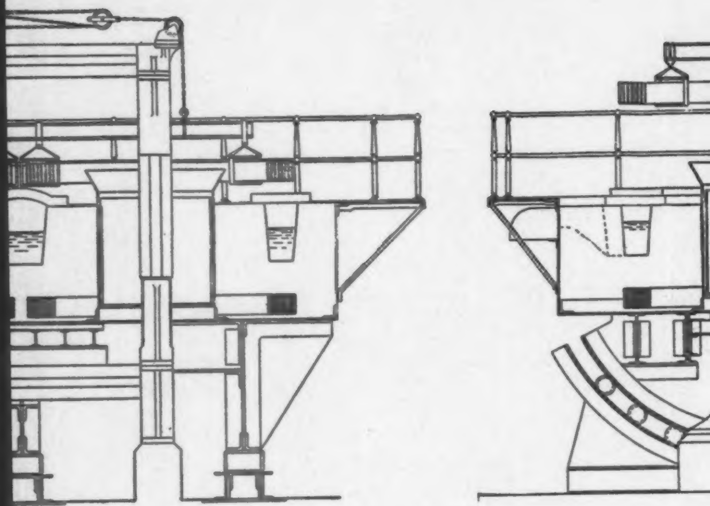




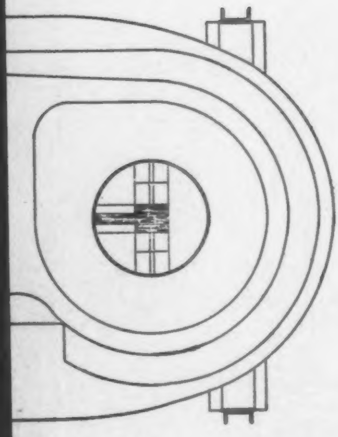
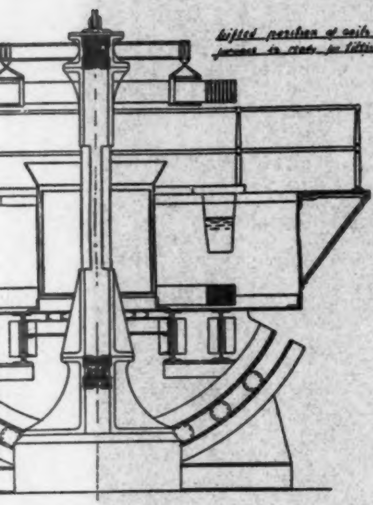


Fig. 10.

General

30 Ton

Albert



l Arrangement of

Tons Furnace.

t Hiorth's Patent.

M = 1:75.

XUM

firmly fixed, to the floor, while the furnace can be tilted for pouring. The central space E is 30 cm. (12 ins.) wide in the middle, 60 cm. (24 ins.) wide at the sides, and nearly 2 meters (76 ins.) long from front to back. It furnishes space enough to re-melt ingots or other scrap.

"Fig. 3 shows a ground plan of the furnace; Fig. 2, a vertical section from right to left; Fig. 4, a vertical section from front to back, through one side, and Fig. 5, a vertical section from front to back, through the center, showing the furnace tilted.

"On the occasion of the writer's visit, the running of the furnace was in charge of Mr. S. Cornthwaite, a Sheffield man, expert in the manufacture and use of crucible steel. The furnace was lined with Veitsch Styrian burnt magnesite, which had been in position for seven weeks, during which it had been occasionally repaired. Norwegian magnesite had been tried and found to crumble badly; it had not been previously properly burnt. The covers were silica slabs, not sufficiently thick, however, to properly protect the melted steel from large radiation losses.

"The materials being melted were the purest obtainable Swedish Dannemora pig-iron from the middle bed of the Dannemora ore deposit, and Dannemora Walloon iron, costing, respectively, $30 (108 kroner) and $75 (270 kroner) per metric ton. These are the identical materials used in Sheffield for crucible melting to produce the best quality of crucible steel. Yellowish-white blast-furnace slag, vitreous and glassy, from the Dannemora furnaces, was being used as a flux, mixed with fluorspar when greater fusibility was desired. The contents of the furnace being five tons, three tons were poured at a time and two tons left in to start the next charge, which then consisted of two tons of raw materials. The analyses of the raw materials and of some steels produced from them are given as:

	C.	Si.	Mn.	S.	P.
Dannemora White Pig	3.80	0.310	1.727	0.025	0.020
Walloon Iron	0.107	0.013	0.068	0.010	0.009
Steel	1.42	0.130	0.322	0.010	0.019
	1.20	0.107	0.269	0.009	0.019
	1.02	0.112	0.301	0.008	0.021
	0.76	0.108	0.253	0.009	0.021
	0.67	0.108	0.288	0.006	0.021

"The details of the heat run off when the writer was present were as follows:

12.20 P. M.	In furnace, 2,775 kg. of previous steel, 1.00 per cent carbon. Charged 1,000 kg. pig iron and 500 kg. Walloon iron. Current started.
12.30 P. M.	Current 1800 A, 273 V, 380 Kw. Cos. ϕ 0.77.
1.30 P. M.	Current 1840 A, 273 V, 395 kw. Cos. ϕ 0.80.
2.00 P. M.	Current 2050 A, 265 V, 380 kw. Cos. ϕ 0.70.
2.30 P. M.	Charge melted. Average current 380 kw. for 2 hrs. 10 min. = 550 kw. hours per ton of metal melted.
2.30 P. M.	Charged 350 kg. pig ion and 1150 kg. Walloon iron.
3.30 P. M.	Current 2275 A, 270 V, kw. Cos. ϕ 0.65.
4.30 P. M.	Charge melted. Average current 400 kw. for 2 hrs. = 530 kw. hours per ton of metal melted.

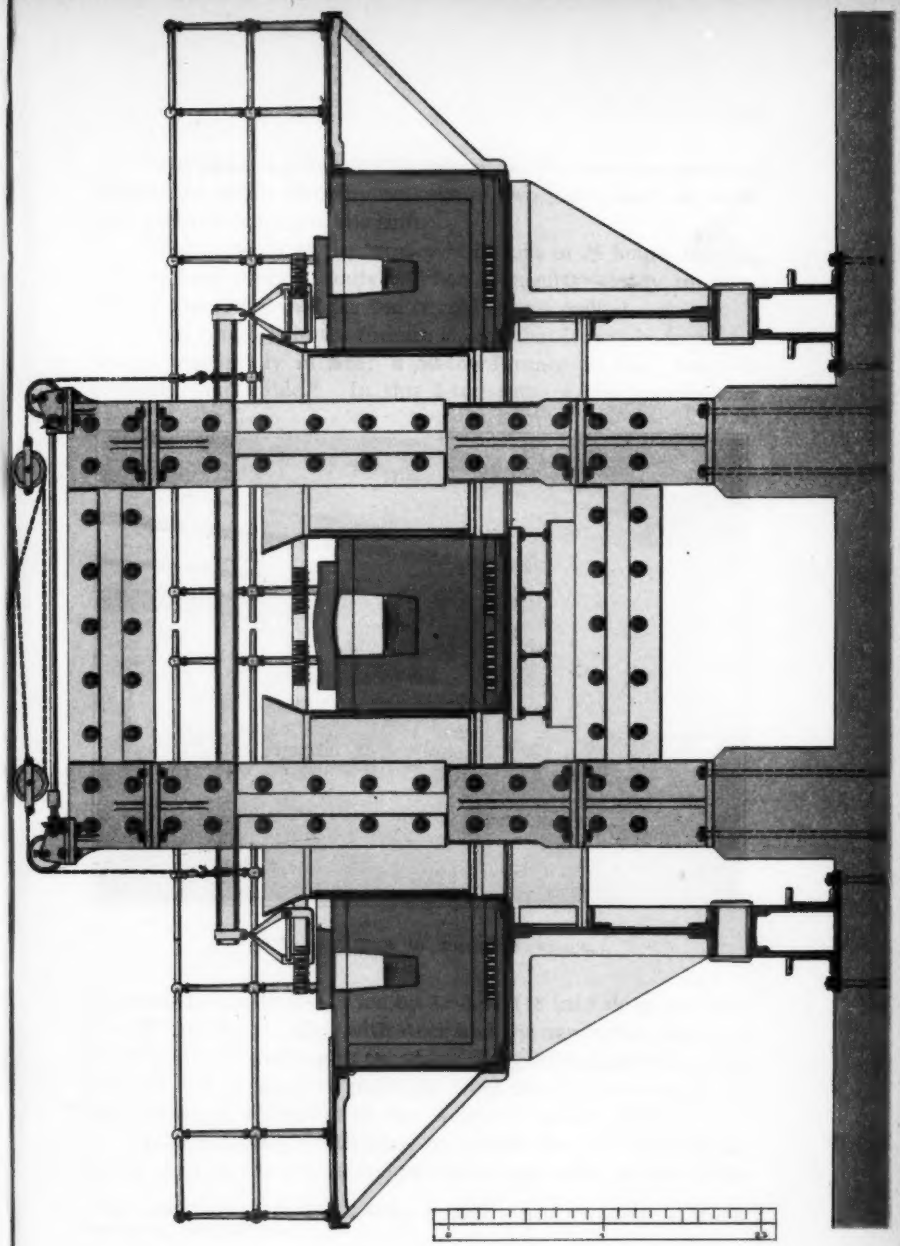
"[Assuming 300 calories necessary to melt 1 kg. of steel, the thermal efficiency of this melting operation is 55 per cent, and the furnace radiation loss calculates out 180 kw., at this temperature. It was stated by Mr. Cornthwaite that it took about 170 kw. to keep the charge melted when the furnace was kept up to heat over night.]

5.30 P. M.	Current 2370 A, 265 V, 395 kw. Cos. ϕ 0.63.
6.00 P. M.	Current 2425 A, 278 V, 400 kw. Cos. ϕ 0.59.
6.15 P. M.	Current 2300 A, 280 V, 365 kw. Cos. ϕ 0.57.

"Metal now at casting temperature. Current used averaged 395 kw. for 6 hours, or 790 kw. hours per ton of steel. As low as 700 kw. hours has been reached in this five-ton furnace on cold materials.

"During the heat, there was added to the bath 35 kg. of 30 per cent ferro-silicon and 8.7 kg. of 80 per cent ferro-maganese; while 0.15 kg, of pure aluminum (= 0.005 per cent of the charge) was added in the ladle.

"The steel was poured into 20 cm. square ingots of one-half ton each, and cast beautifully. These ingots are being shipped to Sheffield for use in the steel works, and metal from this furnace has already given good service for razors, pocket knives, carvers, chisels, axes, files, reamers, taps, drills, turning tools (slow-speed), rock-drills, blacksmiths' tools and engineers' hammers. It sells in competition with crucible steel made from the same materials, the selling price of which is £60 ($293) per ton.



Vertical right-left section of Hiorth furnace

FIG. 2.

"The labor required on this furnace per 24 hours was one head melter, one melter, one boy on each of two shifts, and one ladle man and one helper on one shift.

"The capacity of the furnace is 12 tons in 24 hours, tapping a 3-ton heat every 6 hours. When in regular, steady running, 700 kw. hours are used per ton of cold charge melted.

"The principle of the furnace is such that it may be increased almost indefinitely in size; a 50-ton furnace on this design is certainly practicable.* In this 5-ton furnace the annular ring

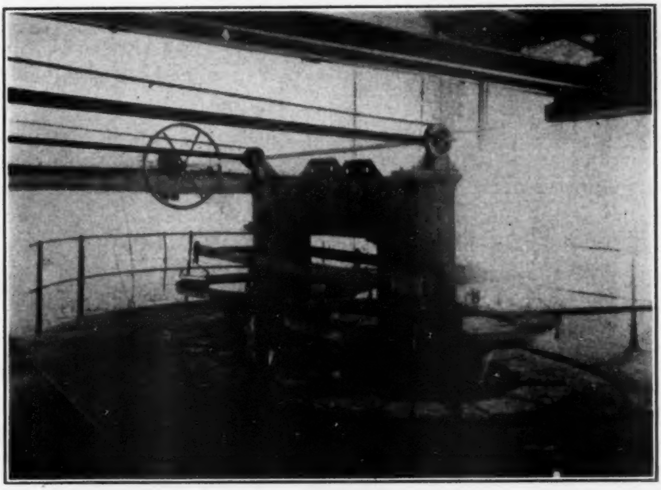


FIG. 6.—TOP VIEW OF HIORTH FURNACE.

channels, 20 cm. (8 ins.) wide by 45 cm. (18 ins.) deep, are only filled 20 cm. (8 ins.) deep with steel, and the narrowness increases the difficulty of working in the slag. Larger furnaces with wider channels will certainly be more free from this arching-over of the slag, because it will fall of its own weight on to the metal.

"It is distinctly worth while to remark that the temperature of the steel in the center compartment was fully as high as in

* See Author's paper: "Design of a 30-Ton Induction Furnace." Trans. Amer. Electrochemical Soc., Vol. XX, 1911.

the annular spaces, even just before the doors. *This shows that, with proper heat-insulating covering over the steel, supplementary heating of the central bath is not a necessity.* It appears to the writer that the difficulty heretofore met at this point is incidental merely to the smallness of the furnaces, and will disappear as larger furnaces are built.

"In conclusion, we may congratulate the Messrs. Hiorth and their very active staff on the high degree of success so far attained by their novel and yet very practical furnace—a furnace which has most of the advantages of the best induction furnaces without some of their serious disadvantages."

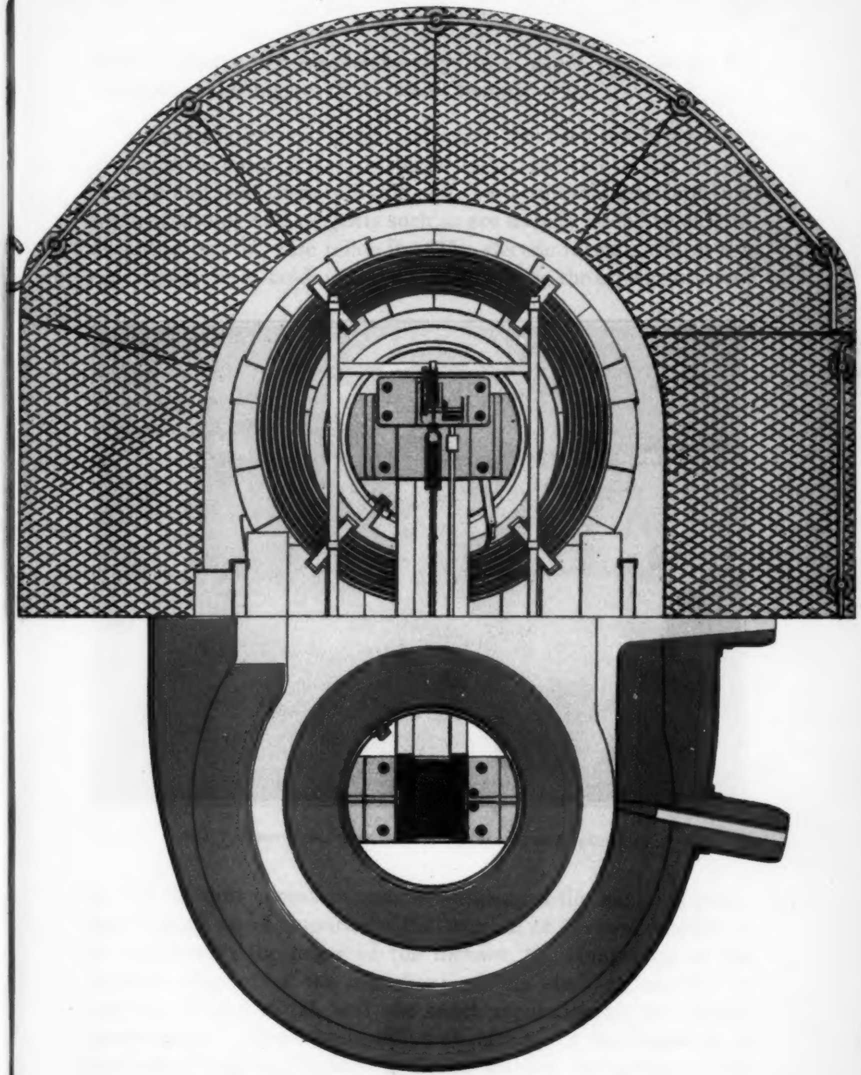
After the inspection of the furnace by Prof. Richards, the construction was altered so as to do away with the hoisting and handling of the upper coils. Fig. 11, illustrating the one-ton furnace, shows this clearly. The upper coils are arranged to allow free accessibility to the bath. Further, no movable connection between the coils is necessary, and the whole construction becomes still simpler, cheaper and more efficient. The lower coil is also better shielded against molten steel breaking through, this always taking its way *inwards* to the center.

The accompanying photos show the five-ton furnace working; Fig. 6 is the view of the top of the furnace showing the charging platform, the lids covering the grooves for the bath, coils and their lifting arrangement, and the top of the magnet. Fig. 7 is a side view of the furnace when tilted for pouring tool-steel.

These photos show the extreme simplicity of the furnace—no insulated copper to be cooled and not to be touched by the workers, no fans for cooling, and the casing only tilted while the heavy magnet rests in place.

This is the device I would recommend for steel casting work, and it will be confined to the rather humble but yet important place in the steel works, as a step in the handling of the molten steel between the open-hearth furnaces (or Bessemer converter) and the pouring ladle.

In countries where energy is not very cheap, the electric furnace can not compete with the older established methods, but it should simply improve the refined steel made by the known methods. About this Prof. Dr. Joseph W. Richards—the electric



Plan and section trough channels of Hiorth furnace

FIG. 3.

furnace expert par excellence—says in a paper read before the International Congress of Applied Chemistry:

"According to his ideas steel which has been finished by any of the well-known processes should be transferred to the electric furnace and held there in liquid state for a suitable length of time without adding any reagents such as are usually added to oxidize, deoxidize or otherwise refine it. The electric furnace will in this case merely be a 'holding furnace,' and among the objects attained

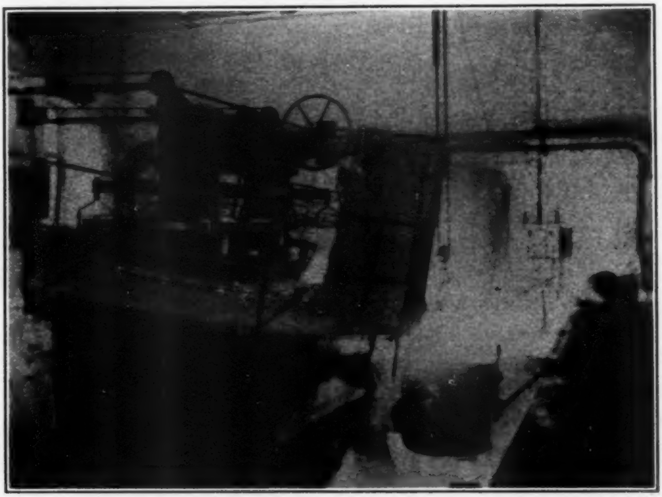


FIG. 7.—POURING TOOL-STEEL FROM HIORTH FURNACE.

by this 'holding operation' may be catalogued the escape of gases, the floating up of impurities, the fixation of evolved impurities by union with the lining of the furnace, the completion of the intimate alloying of the ingredients of the steel, an increase in liquidity cf the metal, and the exact regulation of the casting temperature. Twenty-nine different methods or combinations of methods of ordinary basic or acid steel making, and also including electric melting, are enumerated as processes preceding the final holding operation."

Professor Richards prefers the induction furnace for use in this last step in the series of operations; he also prefers an acid-lined electric furnace and he apparently must be congratulated upon having solved the hitherto open problem of continually operating an induction furnace with an acid lining.

The author of this paper patented already in 1909 his "casting-method" for cylindrical bodies and for casting together irons (or steels) of different qualities (iron shovels in turbine-wheels, cylindrical castings of compound steel for armor plates, etc.). It might perhaps be of interest for this Association to see how this problem was thought conveniently solved.

In Fig. 8 *S* is the sand-mold, *C* is the cylindrical body to be cast. Into this the magnet-core *M* is lowered with the primary coil *p*.

It is easily understood that here *C* corresponds to the channels or grooves for the molten steel in the induction furnace, and here the "bath" (that is, the casting) is heated by the secondary current generated by the primary in *p*.

In this way the casting can be kept fluid and eventually cooled at convenience, as the heat lost in radiation from the mold is supplied electrically.

In this way ingots may be cooled slowly by placing them (top and bottoms connected) around such a coiled magnet-core.

Acting on Prof. Richards' suggestions, the writer has designed his small furnaces especially for steel casting work as described below.

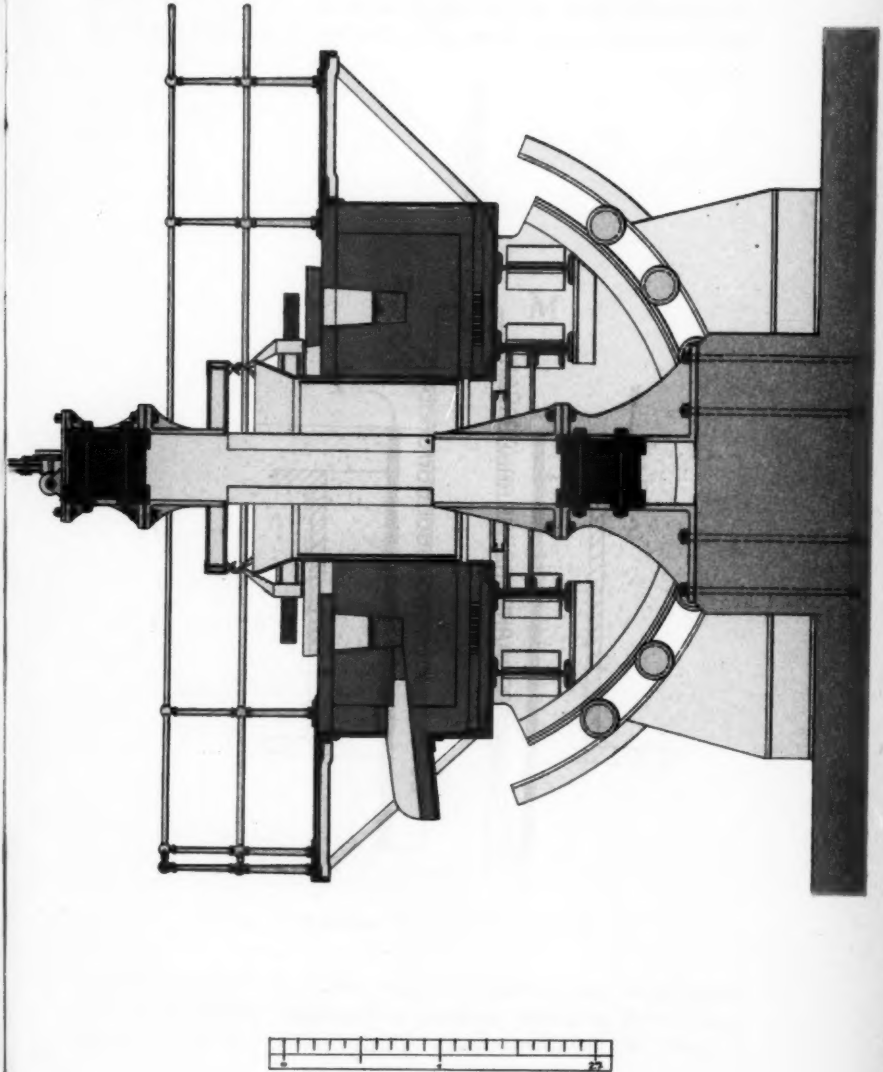
These furnaces are intended for taking part of the contents from existing large steel furnaces (or cupolas) and for converting these smaller quantities by killing and deoxidizing into an extra quality for the finest castings obtainable.

The furnaces are suited to be coupled directly to any existing city current supply and they are calculated to use current of any voltage (here 220 volts) and at about 50 cycles. One phase is here provided; three phase is easily adapted (see Fig. 9).

A 30-ton Hiorth Electric Furnace is shown in Fig. 10.

The weights and dimensions of the smaller furnaces as calculated are given in the table.

In case of refining of steel in induction furnace, the author has also devised a new method for carrying this out in a pure



Vertical front-back section of Hiorth furnace

FIG. 4.

induction furnace (without extra-electrodes of any kind). This consists, in brief, in using the same slag for dephosphorizing as for desulphurizing, in removing the metal under treatment from

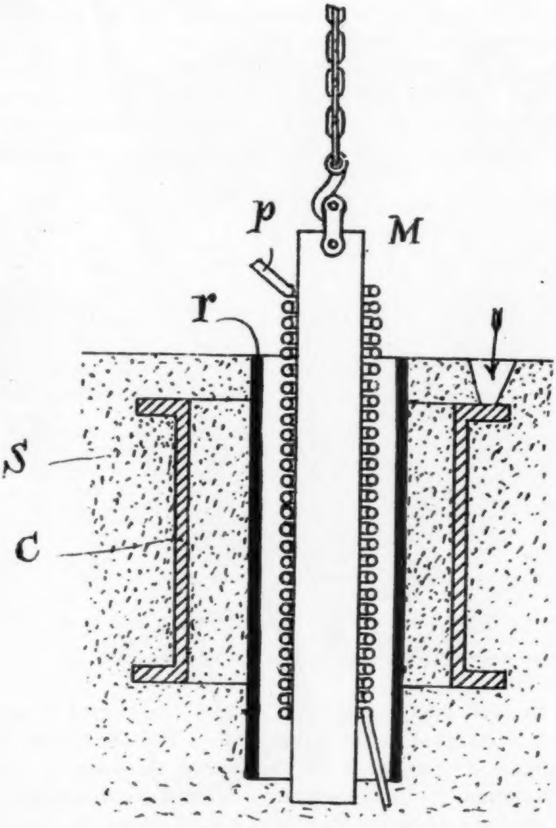


FIG. 8.—ELECTRIC HEATING OF CASTINGS.

contact with the slag after dephosphorization has taken place, and, by a special treatment of the slag, changing it into slag suited for desulphurization, after which treatment the metal is

returned to the furnace and into contact with this suitable desulphurizing slag.

In carrying out the process, the steps ordinarily employed are, in general, as follows: The iron or steel is first dephosphorized in the presence of a highly oxidizing slag suitable for extracting and retaining the phosphorus of the metal. The phosphorus content of the metal is thus reduced to any desired amount, in practice say from 0.06 per cent at the beginning, to about 0.01 per cent or less at the close. The dephosphorization being completed to the desired extent, the metal is poured or tapped from

DATA OF HIORTH INDUCTION FURNACES FOR CASTING STEEL.

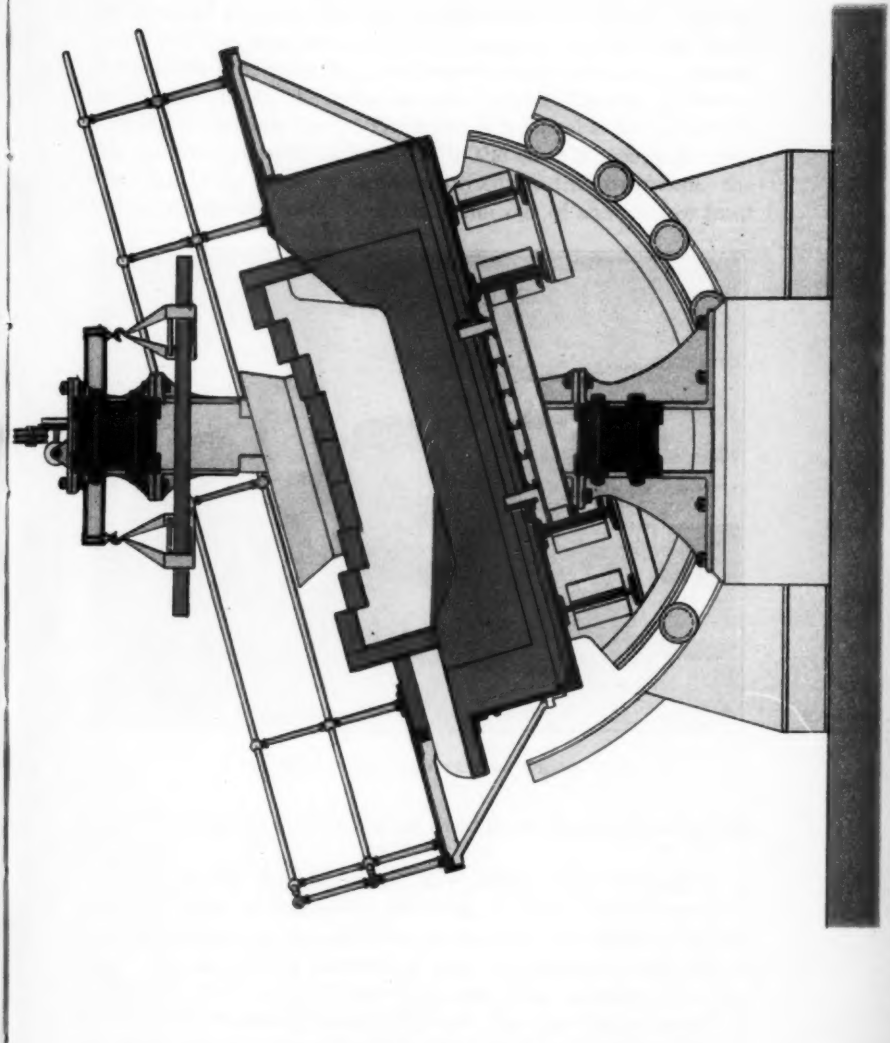
Capacity.	150–300 kg.	1 ton 1000 kg.	5–6 tons. 5000–6000 kg.	30 tons. 30,000 kg.
Diameter of bath	850 mm.	1000 mm.	2100 mm.	3000 mm.
Width of bath	100 mm.	150 mm.	200 mm.	300 mm.
Depth of bath	by 200 kg. charge 77 mm.	127 mm.	270 mm.	450 mm.
Sectional area of magnet core	260 cm.*	22 x 22 cm.	1800 cm.*	1200 cm.*
Weight of magnet core	830 kg. net	1950 kg.	15,000 kg.	23,000 kg.
Number of primary turns per leg	17	17	15	13
Sectional area of primary	350 mm.*	800 mm.*	1,000 mm.*	4000 mm.*
Total weight of copper	256 kg.	755 kg.	1750 kg.	13,500 kg.
Energy used	by 200 kg. charge ca. 70 kw.	175 kw.	250 kw.*	ca. 700 kw.†
Copper losses	1.26 kw.	4.7 kw.	12.3 kw.	40 kw.
Iron losses	2.41 kw.	3.85 kw.	18.— kw.	18 kw.
Power factor	Cos. ϕ 0.74	Cos. ϕ 0.75	Cos. ϕ 0.65	0.50
Voltage	220 Volt	220	250	230
Periodicity	50 per sec.	50	12½	8
Amperes	420	1060	1400	3540
Kind of alternating current	1 Phase	1 Phase	1 Phase	3 Phase

* The data for the 5 tons furnace are *actual readings;* for the other sizes the data are calculated from those of the 5 tons furnace.

† Energy expended for keeping bath molten, not for refining.

under the slag into a ladle or, if desired, transferred to a mixer, where it is retained in the liquid state. The phosphoric slag in the furnace is then ready for the special treatment whereby it is made suitable for desulphurizing. Some of the iron is preferably left in the bath under the slag, or if it is all poured or tapped out, some other iron, such as scrap, may be placed in the furnace, in order to facilitate the special treatment of the slag.

The treatment of the slag, having beneath it a small body of melted iron, consists in charging into the furnace and upon the slag, powdered coal or like carbonaceous material, and closing



Hiorth furnace tilted for pouring

FIG. 5.

the furnace, whereby the slag is subjected to a highly reducing action and the phosphorus which it contains, together with more or less of the iron in the slag, is reduced to the elementary condition and is taken up by the metal beneath the slag, thereby producing a highly phosphoric iron. The latter is a valuable by-product of this operation, useful, for instance, in the basic Bessemer process. The slag being properly dephosphorized by this treatment, the highly phosphoric metal beneath is run out of the furnace from

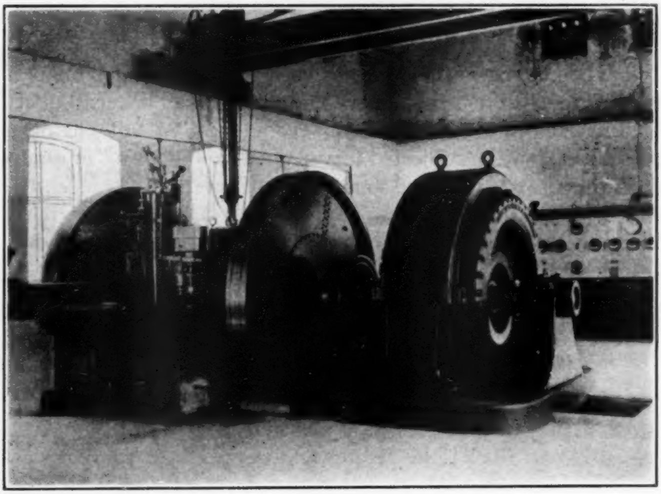


FIG. 9.—DYNAMO AND PELTON WHEEL.

under the slag, the latter being retained in the furnace by a proper slag dam.

The liquid dephosphorized iron which was retained in a ladle or mixer as heretofore described, is then transferred back into the furnace and brought into contact with the dephosphorized slag. By the further addition of more carbonaceous material to reduce the last traces of iron from this slag, together with the addition of sufficient lime and fluorspar, the slag is now converted or changed into a proper desulphurizing slag in contact with which and at a proper furnace temperature and conditions the metal

in the furnace is rapidly and satisfactorily desulphurized. At the end of the desulphurization, the metal is poured or tapped from the furnace in the usual manner.

The operation may be repeated without withdrawing the slag from the furnace, or the slag may be removed from the furnace and a new slag made for a new charge. In either event, the improved practice of this invention requires the formation of only one batch of slag for the two operations of dephosphorization and desulphurization, whereas, as at present universally practiced, it is necessary to produce at least two separate slags to achieve these two objects.

When desulphurization has been completed, the metal in the furnace, before being removed therefrom, may be recarburized, or converted into special steel by the addition of suitable alloys, or, in brief, may be subjected to any of the well known "finishing" operations incident to the final stages of treatment of steel after dephosphorization and desulphurization. During these operations, the slag in the furnace may be partly or wholly removed, if so desired.

A STUDY OF THE ANNEALING PROCESS FOR MALLEABLE CASTINGS.

By E. L. Leasman, Boscobel, Wis.

Introduction.

The present development of the malleable casting industry has reached enormous proportions, approximating a million tons per annum. The technique of the industry, however, has advanced but little.

The first record we have is by Reaumur, in 1722. Without doubt, however, the malleableizing process was practiced much earlier, the secret being handed down from father to son.

Seth Boyden, of Newark, N. J.; was the pioneer manufacturer in this country. Although he did not discover the underlying principles involved, yet his recorded experiments are the first we have, and he deserves special credit inasmuch as they were made at a time when scientific experimentation on industrial problems was frowned upon.

Malleable cast iron occupies a position between ordinary cast iron and cast steel. It has a higher tensile strength than cast iron, but not as high as that of cast steel, while its resilience is superior to either.

The method of producing malleable castings is fairly uniform throughout the country. The white iron castings are packed in rolling mill scale in rectangular iron containers. These containers, either three or four high, are carefully luted up to exclude currents of air, placed in the ovens, and heated up to the desired temperature, keeping them at the high point at least sixty hours. The total time of the annealing process is a week from one time of "lighting-up" to the next time.

The Metallography of White Cast Iron.

The white cast iron (hard casting) used in the production of malleable castings must have the proper composition for the

work at issue, and must be properly melted. The accompanying three illustrations give the characteristic microstructures.

Fig. 1 shows a typical white cast iron structure. The white areas represent the iron carbide, or cementite, which was not attacked by the etching reagent, picric acid. The dark areas are pearlite and are composed of plates of cementite and ferrite. The general structure of Figs. 2 and 3 is the same, but there being more white areas in Fig. 2 shows that a larger percentage is present.

Fig. 1 was taken from a sample which contained steel scrap in the charge. It shows a different structure than that of the other two samples; the areas of pearlite being round in form. Also, the white areas are not as prominent, showing that there was not as much carbon present. This is to be expected, as steel scrap is generally added to the iron melt to cut down the percentage of carbon in the resulting white iron casting.

The analysis of the hard castings would run about as follows:

Total carbon (all combined)	2.75 to 3.25
Silicon	0.50 to 1.00
Sulphur	below 0.08
Phosphorus	below 0.225
Manganese	0.15 to 0.40

Cast iron is a complex alloy of iron with carbon and the other elements above listed. The state of the carbon is of the most importance and the other elements are secondary and influence the state of the carbon. Carbon is associated with iron in three different states, namely: as a definite carbide known as cementite, with the formula Fe_3C; as free carbon or graphite; and as a solid solution of carbon or combined carbon (carbide) in iron.

Of the secondary elements, silicon exerts the greatest influence on the state of the carbon, and tends to form graphitic carbon. Sulphur and manganese tend to form combined carbon. In the casting of white iron, the silicon content is so controlled that its influence during the cooling of the casting will not be great enough to precipitate out the carbon as free graphite, but allow it to remain in the combined form as iron carbide.

FIG. 1.

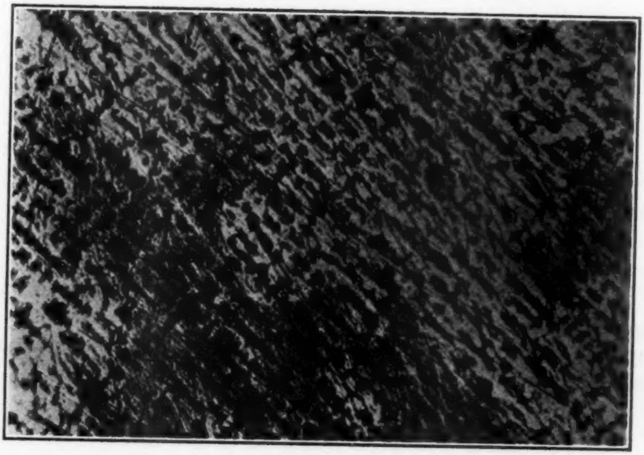


FIG. 2.

Effect of Heat Treatment.

When white iron is heated sufficiently, the cementite, both the excess and that present in the eutectoid, is broken down into its constituents of iron and carbon, according to the reaction,

$$Fe_3C = 3Fe + C$$

This change may result from a high heat for a short period of time, or from a lower heat for a longer period of time.

The temperature and time necessary to effect this change depends upon the composition of the white iron. The three elements which will determine these effects are: silicon, manganese and sulphur. The silicon will tend to lower the temperature since this element prevents the formation of combined carbon. By increasing the manganese content, the temperature must be raised since it tends to keep the carbon in the combined form. Sulphur also has the tendency to exert the same influence.

Not only must the temperature be high enough and the time long enough to break down the cementite in the white iron, but the material must be cooled slowly or a steely structure will result.

When cast iron is properly malleableized, the carbide is entirely broken down into its elements, and the carbon is precipitated out as globules of amorphous carbon, surrounded by pure ferrite. Carbon in this form is known as temper carbon and does not occur in flakes as in gray cast iron.

Fig. 4 shows the interior structure of malleable cast iron. The white field is ferrite and the dark spots are particles of temper carbon.

The Purpose of this Study.

As the data available in connection with the annealing process for making malleable castings are so meagre, the investigation to be detailed in what follows was undertaken. Four lines of study were mapped out, as follows:

1. The effect of different packing materials.
2. The effects of different annealing temperatures.
3. The effects of different times of annealing.
4. The effect of different times of cooling.

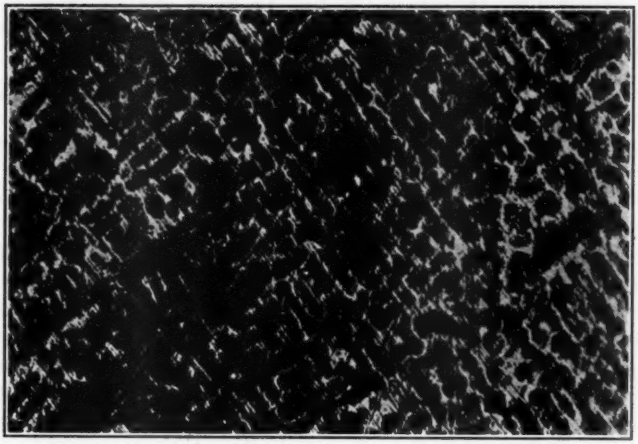


FIG. 3.

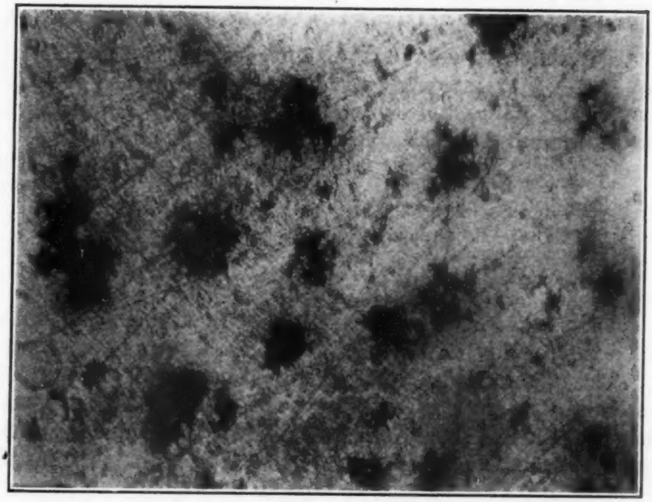


FIG. 4.

There may be said to be five variables entering into the annealing process, namely:

1. Packing materials used.
2. Time of bringing up the oven to maximum temperature desired.
3. Temperature of annealing.
4. Time of annealing.
5. Time of cooling.

Since the second variable is dependent entirely upon the type of oven used, and since it is well known that the rate of heating up the oven does not affect the resulting castings, this variable will not enter into the investigation at all. By arranging matters so that three variables out of the four are kept constant for each series of experiments, the other variable could be studied. The result should be of value as indicating the best conditions for proper annealing, as well as giving an abundance of data on the influence of the several variables.

Materials Used.

The white iron used for these tests was in the shape of test bars $\frac{3}{4}$ x $\frac{3}{4}$ x 10 ins., and were courteously furnished by the Beaver Dam Malleable Iron Company. Mr. W. G. Grimer, their chemist, furnished the following analysis with the bars:

Total (combined) carbon	2.60 to 2.70
Silicon	0.65 to 0.70
Sulphur	0.55 to 0.60
Phosphorus	0.140
Manganese	0.27

The packing material consisted of the usual rolling mill scale and a variety of other materials, as given in the tests themselves.

The containers for holding the specimens (broken from the test bars) were made of $1\frac{1}{2}$ in. pipe, cut to length to take specimens about 2 ins. long. These containers were luted up with fire clay, except where caps and nipples were used. The latter are noted in the experiments as "Special Boxes."

The two muffles used were of the electric type. They were built by the author in the Chemical Engineering Laboratory of

the University of Wisconsin, and consisted of muffles heated electrically by resistance wires.

The pyrometers were couples supplied by the laboratory and standardized against regular platinum—Pt. Rhodium couples.

One of the electric muffles was controlled by means of a lamp bank in series with the furnace, and was supplied with current from a 110-volt alternation current circuit. The other furnace was on a 220-volt alternating current circuit, and the pressure was regulated by means of a low voltage transformer. The current was regulated by means of a lamp bank in series with the primary coil of the transformer.

The Effect of Various Packing Materials.

Experiment No. 1.

No. 1. Packed in lime. Fairly heavy scale on specimen; packing adherent but easily removed.

No. 2. Packed in sand. Fairly heavy scale on specimen, with sand adherent and colored red.

No. 3. Packed in alundum. Specimen surrounded with a hard shell, which was easily removed, and left the specimen clean and colored red.

No. 4. Packed in rolling mill scale. Fairly heavy, tenacious scale; packing adherent.

No. 5. Packed in resister carbon. Packing not adherent to specimen, which had a blue and red color.

No. 6. Packed in manganese dioxide. Specimen and container heavily attacked; specimen covered with a shell about $\frac{1}{16}$ in. thick, which was easily removed and left the specimen clean and blue in color.

No. 7. Packed in neat cement. Packing disintegrated and not adherent.

No. 8. No packing. Heavy, tenacious scale formed.

Experiment No. 2.

No. 9. Packed in coarse fire clay. Fairly heavy scale; packing adherent.

No. 10. Packed in fine rolling mill scale. Heavy scale.

No. 11. Packed in pure iron oxide. Fairly heavy scale; packing adherent and brown in color.

No. 12. Packed in fine graphite. Specimen clean; packing hard.

No. 13. Packed in alumina. Fairly heavy scale; packing adherent.

No. 14. Packed in chromite. Heavy scale; packing adherent.

No. 15. Packed in brass turnings. Packing fused and adherent.

No. 16. No packing. Specimen at end of furnace. Coated with heavy black scale.

Experiment No. 3.

No. 16. Packed in Portland cement. Fairly heavy scale; packing tenaciously adherent.

No. 17. Packed in bauxite. Heavy scale easily removed; packing adherent.

No. 18. Packed in hydrated magnesia. Fairly heavy scale; packing somewhat adherent.

No. 19. Packed in fine fire clay. Specimen clean; packing hard and pinkish in color.

No. 20. Packed in ordinary iron oxide. Heavy scale; packing adherent and lumpy.

No. 21. Packed in carborundum. Thin scale; packing adherent.

No. 22. No packing. Standing in center of furnace. Heavy scale formed.

Experiment No. 1. Heat Treatment Data.

Hours.........	3	17	20	26	29	40	52	55	65	76	90	93	98	104
Temperature...	1615	1630	1610	1650	1620	1650	1650	1540	1490	1330	1310	1250	900	520

Annealing temperature of 1660° to 1650° F. maintained for 50 hours, and time of cooling also 50 hours, 20 of which to 1390°, 18 to 1250° F. and 12 hours to 500° F.

MICROSCOPIC EXAMINATION.

No. 1. Packed in lime. Edge: temper carbon and ferrite. Center: temper carbon and ferrite.

No. 2. Packed in sand. Edge: temper carbon and ferrite. Center: temper carbon and ferrite.

No. 3. Packed in alundum. Edge: thin layer of ferrite; high carbon steel. Center: temper carbon and pearlite.

No. 4. Packed in rolling mill scale. Edge: ferrite and pearlite. Center: temper carbon and ferrite.

No. 5. Packed in resister carbon. Edge: ferrite and pearlite. Center: temper carbon; ferrite and pearlite.

No. 6. Packed in manganese dioxide. Edge: heavy layer of pure ferrite. Center: temper carbon and ferrite.

No. 7. Packed in neat cement. Edge: pure ferrite. Center: temper carbon and ferrite.

No. 8. No packing. Edge: temper carbon and ferrite. Center: temper carbon and ferrite.

Experiment No. 2. Heat Treatment Data.

Hours..........	4	10	15	30	50	60	68	71	81	86	93	108
Temperature....	1200	1640	1650	1650	1650	1650	1400	1340	1290	1100	900	520

Annealing temperature of 1650° F. maintained for 50 hours, and time of cooling also 50 hours: 9 hours to 1390° F., 13 hours to 1250° F. and 28 hours to 500° F.

Microscopic Examination.

No. 9. Packed in coarse fire clay. Edge: ferrite and pearlite. Center: Low carbon steel and temper carbon.

No. 10. Packed in rolling mill scale. Edge: ferrite and high carbon steel. Center: mild steel and temper carbon.

No. 11. Packed in pure iron oxide. Edge: ferrite and high carbon steel. Center: medium carbon steel and temper carbon.

No. 12. Packed in fine graphite. Edge: ferrite and high carbon steel. Center: Medium carbon steel and temper carbon.

No. 13. Packed in alumina. Edge: ferrite. Center: medium carbon steel and temper carbon.

No. 14. Packed in chromite. Edge: ferrite and pearlite. Center: Pearlite and temper carbon.

No. 15. Packed in brass turnings. Edge: yellow metal and pearlite. Center: pearlite and temper carbon.

Experiment No. 3. Heat Treatment Data.

Hours..........	5	9	10	20	30	40	50	60	60	70	84	98	109
Temperature....	1330	1600	1680	1660	1670	1670	1670	1670	1450	1290	1100	900	540

Annealing temperature of 1650° F. maintained for 50 hours. Time of cooling: 5 hours to 1390° F., 10 hours to 1250° F., 35 hours to 500° F.; 50 hours in all.

Microscopic Examination.

No. 16. Packed in Portland cement. Edge: ferrite and pearlite. Center: pearlite and temper carbon.

No. 17. Packed in bauxite. Edge: ferrite and pearlite. Center: pearlite and temper carbon.

No. 18. Packed in hydrated magnesia. Edge: ferrite and pearlite. Center: pearlite and temper carbon.

No. 19. Packed in fine fire clay. Edge: ferrite and pearlite. Center: pearlite and temper carbon.

No. 20. Packed in iron oxide. Edge: ferrite and pearlite. Center: pearlite and temper carbon.

No. 21. Packed in carborundum. Edge: ferrite and pearlite. Center: pearlite and temper carbon.

No. 22. No packing used. Edge: ferrite and pearlite. Center: ferrite and temper carbon.

The results obtained by the use of various packing materials warrants the conclusion that they have no important effect upon the interior structure of malleable iron. However, it is noticeable that those packings which are not stable at the annealing temperature used have seemingly been the most active in

causing a removal of the carbon from and near the surface of the specimen.

The surface or skin effect is dependent upon the nature of the packing used and also upon the method of packing; that is, whether the materials are loosely packed and allow free access of the oxygen in the air. Where an oxidizing packing is used, or where a specimen is loosely packed, the carbon was entirely removed from the outside portion of the specimen.

Where a packing was used which would pack closely about the specimen, such as fine fire clay, the decarbonization took place only to a limited extent. In this case the carbon remained as a pearlitic structure of varying thickness. Experiments were run with carbon in various forms (see also Experiments No. 16, 17 and 18) as the packing materials, and a pearlitic structure generally obtained as a skin effect.

These experiments resulted in the following conclusions: The presence of oxygen is necessary for the decarbonization of the surface, and that this oxygen is supplied by the air and finds its way to the specimen owing to the looseness of the packing material.

These experiments also show that a rapid rate of cooling causes the formation of steel as the interior structure of the specimen.

The Effect of Different Temperatures of Annealing.

Experiment No. 4.

No. 23. Packed in resister carbon. Fairly heavy scale; packing burned to ash.

No. 24. Packed in iron oxide. Thin scale; packing not adherent.

No. 25. Packed in sand containing 10 per cent resister carbon by volume. Sand tenaciously adherent; fairly heavy scale hard to remove.

No. 27. Packed in rolling mill scale. Fairly heavy scale; packing caked hard but not adherent.

No. 28. Packed in rolling mill scale. This specimen had previously been heated for several hours at 1600° F.

No. 29. No packing. Fairly heavy scale.

Experiment No. 5.

No. 30. Packed in resister carbon. Thin scale; packing brown in color, and not tenaciously adherent.

No. 31. Packed in iron oxide. Heavy scale; packing blue in color and tenaciously adherent.

No. 32. Packed in iron oxide containing 10 per cent of resister carbon by volume. Fairly heavy scale; packing blue in color and tenaciously adherent.

No. 33. Packed in fine fire clay. Thin scale; packing adherent and yellowish in color.

No. 34. Packed in rolling mill scale. Fairly heavy scale; packing adherent; specimen red in color.

No. 35. Packed in graphite. Previous heated specimen.

No. 36. Gray iron packed in resister carbon. Fairly heavy scale; packing adherent.

No. 37. No packing. Thin scale; specimen blue in color.

Experiment No. 6.

No. 38. Packed in resister carbon. Packing burned at ash at ends of specimen, where a fairly heavy scale was formed. Specimen so hard that saw would only touch the outside.

No. 39. Packed in iron oxide. Packing slightly adherent. Specimen too hard to saw.

No. 40. Packed in iron oxide containing 25 per cent of graphite by volume. Thin scale; packing not adherent. Specimen too hard to saw.

No. 41. Packed in rolling mill scale with 10 per cent of graphite by volume. Thin scale; packing somewhat adherent. Specimen too hard to saw.

No. 42. Packed in rolling mill scale. Thin scale. Specimen soft enough to saw in two.

No. 43. Packed in sand containing 25 per cent of resister carbon by volume. Thin scale; packing adherent. Specimen too hard to saw.

No. 44. No packing. Thin scale. Specimen too hard to saw.

No. 45. Packed in rolling mill scale. Fairly heavy scale, tenaciously adherent. Specimen too hard to saw.

Experiment No. 7.

No. 38a. Packed in resister carbon. Packing burned to ash at ends and slightly adherent. Specimen too hard to saw. This specimen was at end of furnace.

No. 39a. Packed in iron oxide. Thin scale; packing slightly adherent. Specimen too hard to saw. This specimen was at end of the furnace.

No. 41a. Packed in scale containing 10 per cent of graphite. Fairly heavy scale; packing adherent. Specimen very hard to saw in two. This specimen at center of furnace.

No. 43a. Packed in sand containing 25 per cent of resister carbon. Fairly heavy scale with packing adherent. Specimen very hard to saw. This specimen at center of furnace.

No. 44a. No packing. Thin scale. Specimen very hard to saw. This specimen at center of furnace.

No. 45a. Packed in rolling mill scale. Thin scale with adherent packing. Specimen hard to saw. This specimen at end of furnace.

Experiment No. 8.

No. 46. Packed in resister carbon. Packing burned to ash at ends where it was adherent to specimen. Too hard to saw.

No. 47. Packed in iron oxide. Very thin scale with packing not adherent. Too hard to saw.

No. 48. Packed in sand containing 25 per cent resister carbon by volume. Thin scale with packing somewhat adherent. Too hard to saw.

No. 49. Packed in rolling mill scale. Very thin scale with packing slightly adherent. Too hard to saw.

No. 50. Packed in rolling mill scale. Thin scale with packing somewhat adherent. This specimen had previous treatment for a few hours. Specimen hard to saw.

No. 51. Packed in scale containing 25 per cent of resister carbon by volume. Thin scale with packing somewhat adherent. Too hard to saw.

No. 52. Packed in chromite. Thin scale with packing not adherent. Too hard to saw.

No. 53. No packing. Thin scale. Too hard to saw in two; saw went in about $\frac{1}{8}$ in.

Experiment No. 9.

No. 54. Packed in graphite in special box. No scale with packing not adherent.

No. 55. Packed in fine fire clay in special box. No scale with packing dark in color and not adherent.

No. 56. Packed in graphite. Thin scale with packing burned at ends.

No. 57. Packed in rolling mill scale. Thin scale with packing adherent and caked.

No. 58. Packed in fine fire clay. Very thin scale slightly adherent.

Experiment No. 10.

No. 59. Packed in scale in special box. No scale with packing not adherent. Too hard to saw.

No. 60. Packed in rolling mill scale. Fairly heavy scale with packing adherent. Very hard to saw in two.

No. 61. Packed in graphite in special box. No scale with packing not adherent. Hard to saw in two.

No. 62. Packed in graphite. No scale with packing not adherent. Not easy to saw.

No. 63. Packed in fine fire clay. Thin scale with packing tenaciously adherent.

No. 64. Packed in fine fire clay containing 10 per cent of graphite by volume. Thin scale with packing tenaciously adherent. Too hard to saw. Specimen at end of furnace.

No. 65. No packing. Thin scale. Too hard to saw. Specimen at end of furnace.

Experiment No. 4. Heat Treatment Data.

Hours..............	2	5	15	27	38	49	54	70	87	92	99
Temperature.........	1300	1500	1540	1480	1510	1520	1510	1120	890	740	510

Annealing temperature of 1500° F. maintained for 50 hours. Time of cooling, also 50 hours: 4 hours to 1390° F., 5 hours to 1250° F. and 41 hours to 500° F.

MICROSCOPIC EXAMINATION.

On account of specimens being too hard to saw, no sections were made for Nos. 23, 24, 25, 26, 27 and 29, of this experiment.

No. 28. Packed in scale. Previously treated. Edge: ferrite, temper carbon and pearlite. Center: temper carbon and pearlite.

Experiment No. 5. Heat Treatment Data.

Hours..............	5	6	15	21	28	48	55	67	79	92	105
Temperature.........	1150	1390	1440	1360	1400	1400	1380	1070	880	700	540

Annealing temperature of 1400° F. maintained for 50 hours. Time of cooling, also 50 hours: 1 hour to 1390° F., 4 hours to 1250° F. and 45 hours to 500° F.

MICROSCOPIC EXAMINATION.

No. 30. Packed in resister carbon. Edge: ferrite and pearlite. Center: temper carbon and ferrite.

Nos. 31 and 32. Packed in iron oxide and oxide with carbon. Edge: ferrite. Center: ferrite and temper carbon.

No. 33. Packed in fine fire clay. Edge: ferrite. Center: ferrite, temper carbon and pearlite.

No. 34. Packed in scale. Edge: ferrite. Center: ferrite, pearlite and cementite.

No. 35. Packed in graphite. Previously treated. Edge: ferrite. Center: ferrite; cementite and temper carbon.

No. 36. Gray iron. No change in structure.

No. 37. No packing. Edge: ferrite. Center: ferrite; temper carbon and cementite.

Experiment No. 6. Heat Treatment Data.

Hours.............	2	4	25	40	52	61	72	86	94	103
Temperature........	820	1320	1320	1320	1300	1090	920	680	610	520

Annealing temperature of 1300° F. maintained for 50 hours. Time of cooling, also 50 hours: 1 hour to 1250° F. and 49 hours to 500° F.

MICROSCOPIC EXAMINATION.

No. 42. Packed in scale. Previously treated. Edge: ferrite and pearlite. Center: only slightly changed.

All of the rest of the specimens were too hard to saw.

Experiment No. 7. Heat Treatment Data.

Hours	2	2	14	35	51	59	71	85	86	95	100
Temperature	900	1350	1350	1380	1350	1200	1150	950	850	680	520

Annealing temperature of 1350° F. maintained for 50 hours. Time of cooling, also 50 hours: 7 hours to 1250° F. and 43 hours to 500° F.

MICROSCOPICAL EXAMINATION.

All of the specimens obtained in this experiment were either too hard to cut or, after being examined, showed very little change in structure from the white iron.

Experiment No. 8. Heat Treatment Data.

Hours	3	10	31	46	57	66	80	83	100	116
Temperature	1050	1250	1240	1180	1230	1080	920	1200	1250	1080

Annealing temperature of 1000° to 1200° F. maintained for 120 hours. Time of cooling to 500° F., 36 hours.

MICROSCOPICAL EXAMINATION.

No. 50. Packed in scale. Previously treated. Edge: ferrite and temper carbon. Center: not entirely changed.

All of the rest of the specimens were too hard to saw.

Experiment No. 9. Heat Treatment Data.

Hours	1	3	18	26	32	50	68	80	90	100	103
Temperature	700	1510	1520	1550	1530	1530	1330	1120	1050	880	520

Annealing temperature of 1500° to 1550° F. maintained for 50 hours. Time of cooling, also 50 hours: 10 hours to 1390° F., 8 hours to 1250° F. and 32 hours to 500° F.

MICROSCOPICAL EXAMINATION.

No. 54. Packed in graphite. Special box. Edge: pearlite. Center: Not completely changed.

No. 55. Packed in fine fire clay. Special box. Edge: ferrite and pearlite. Center: about half changed.

No. 56. Packed in graphite. Edge: ferrite and pearlite. Center: fairly well changed.

No. 57. Packed in scale. Edge: ferrite and pearlite. Center: fairly well changed.

No. 58. Packed in fine fire clay. Edge: ferrite and pearlite. Center: ferrite; temper carbon and a little cementite.

Experiment No. 10. Heat Treatment Data.

Hours	6	6	30	50	55	61	71	80	88	102	108
Temperature	1320	1460	1470	1470	1470	1330	1180	1100	1090	950	520

Annealing temperature of 1450° to 1475° F. maintained for 50 hours. Cooling time, 50 hours also: 6 hours to 1390° F., 6 hours to 1250° F. and 38 hours to 500° F.

MICROSCOPICAL EXAMINATION.

All of the specimens in this experiment were either too hard to saw or showed that the original white iron structure was very slightly changed.

From the result obtained in this series of experiments the conclusion is reached that for white iron of the analysis furnished, and under the experimental conditions obtaining, a temperature of up to 1400° F. is necessary to cause a complete breaking down of the cementite into ferrite and temper carbon.

Experiment No. 8 shows that the specimens heated for 120 hours at 1000° to 1200° F. were still unchanged; with the exception of specimen No. 50, which had previously been heated for a number of hours at 1600° F., and whose interior structure was still not completely changed.

The same general results hold true for Experiment No. 6, where the annealing temperature was 1300° F., and the period of heating was 50 hours.

The results of Experiment No. 5, where the annealing temperature was 1400° F., show that only those specimens at the center of the furnace were well changed, while those near the door (or colder) still had some cementite present.

The same general results hold true for Experiments No. 4 and No. 10, so that for the following experiments an annealing temperature of 1550 to 1650° F. will be used as the constant.

THE EFFECTS OF DIFFERENT PERIODS OF COOLING FROM THE ANNEALING TEMPERATURE TO 500° F.

Experiment No. 11.

No. 66. Packed in graphite. Packing burned to ash at ends, where a fairly heavy scale was formed.

No. 67. Packed in scale. Heavy scale; packing adherent and caked.

No. 68. Packed in fine fire clay. Fairly heavy and tenacious scale; packing adherent.

No. 69. Packed in scale containing 25 per cent of graphite by volume. Heavy scale; adherent packing.

No. 70. Packed in chromite. Very heavy scale; adherent packing.

No. 71. No packing. Heavy scale.

No. 72. Packed in fine fire clay containing 25 per cent of graphite by volume. Heavy scale; adherent packing.

Experiment No. 12.

No. 73. Packed in scale. Fairly heavy and tenacious scale; adherent packing.

No. 74. Packed in scale containing 25 per cent of graphite, in special box. No scale; specimen clean.

No. 75. Packed in chromite. Fairly heavy scale; adherent packing.

No. 76. Packed in fine fire clay. Heavy scale; adherent packing.

No. 77. Packed in graphite. Packing burned and adherent; fairly heavy scale.

No. 78. Packed in iron oxide. Fairly heavy, tenacious scale; adherent packing.

No. 79. No packing. Heavy scale.

No. 80. Packed in sand containing 25 per cent of graphite by volume. Heavy, tenacious scale; packing adherent.

Experiment No. 13.

No. 81. Packed in scale in special box. Thin scale; packing not caked.

No. 82. Packed in graphite in special box. No scale.

No. 83. Packed in scale. Heavy and tenacious scale with packing adherent.

No. 84. Packed in graphite. Heavy scale; packing burned.

No. 85. Packed in a mixture of fire clay and neat cement. Packing disintegrated and not adherent.

No. 86. Packed in chromite. Heavy scale; adherent packing.

No. 87. No packing. Heavy scale.

Experiment No. 14.

No. 88. Packed in scale in special box. Thin scale; packing caked.

No. 89. Packed in scale. Heavy and tenacious scale; with packing adherent.

No. 90. Packed in fine fire clay. Heavy scale easy to remove; packing somewhat adherent.

No. 91. Packed in graphite. Heavy and tenacious scale; packing burned.

No. 92. No packing. Heavy scale.

Experiment No. 15.

No. 93. Packed in bone black in special box. No scale; packing not burned.

No. 94. Packed in scale in special box. No scale; packing caked.

No. 95. Packed in fine fire clay. Fairly heavy scale; adherent packing.

No. 96. Packed in scale. Fairly heavy and tenacious scale; adherent packing.

No. 97. No packing. Heavy and tenacious scale.

No. 98. Packed in chromite containing 25 per cent of bone black. Fairly heavy and tenacious scale; packing adherent.

Experiment No. 16.

No. 99. Packed in bone black in special box. No scale; packing somewhat burned at one end.

No. 100. Packed in fine fire clay in special box. No scale.

No. 101. Packed in fine fire clay. Heavy scale; packing adherent.

No. 102. Packed in scale. Heavy and tenacious scale; packing adherent.

No. 103. Packed in scale in special box. Specimen clean; packing gray in color.

No. 104. No packing. Heavy scale.

No. 105. Packed in iron oxide containing 25 per cent of bone black. Fairly heavy and tenacious scale.

Experiment No. 11. Heat Treatment Data.

Hours	1	2	6	19	23	31	49	52	63	71
Temperature	970	1460	1470	1660	1590	1620	1630	1610	1611	520

Annealing temperature of 1600° F. maintained for 39 hours. Cooling time, 14 hours from maximum to 500° F.

NOTE.—Furnace burned out, allowing a very rapid cooling to take place.

No. 66. Packed in graphite. Edge: ferrite and pearlite. Center: pure pearlite.

The rest of the specimens in this experiment showed in: ferrite and pearlite. Center: high carbon steel.

Experiment No. 12. Heat Treatment Data.

Hours	1	2	7	10	46	54	60	71	83	93	99	103
Temperature	1130	1480	1530	1490	1480	1470	1400	1400	1140	1100	980	520

Annealing temperature of 1450° to 1500° F. maintained for 50 hours. Cooling time of 50 hours also: 18 hours to 1390° F., 7 hours to 1250° F. and 25 hours to 500° F.

Nos. 76 and 77, which were in the center of the furnace, showed a fairly good structure. The rest of the specimens showed an edge of ferrite, with the interior not completely changed.

Experiment No. 13. Heat Treatment Data.

Hours	2	5	13	22	33	51	70	83	100	116	120
Temperature	1080	1530	1630	1550	1580	1540	1520	1410	1390	1250	720

Annealing temperature of 1550° to 1600° F. maintained for 50 hours. Cooling time, 70 hours: 45 hours to 1390° F., 15 hours to 1250° F. and 10 hours to 500° F.

All the specimens in this experiment showed a good structure, both edge and center.

Experiment No. 14. Heat Treatment Data.

Hours	1	5	14	19	27	39	63	78	90	92
Temperature	1110	1530	1590	1530	1560	1520	1520	1370	1230	700

Annealing temperature of 1550° F. maintained for 50 hours. Cooling time, 40 hours: 24 hours to 1390° F., 12 hours to 1250° F. and 4 hours to 500° F.

All of the specimens in this experiment showed the same general structure, as follows: Edge: ferrite and pearlite. Center: temper carbon, ferrite and pearlite.

Experiment No. 15. Heat Treatment Data.

Hours	2	12	32	40	57	80	91	102	108
Temperature	980	1520	1580	1530	1570	1480	1390	1250	520

Annealing temperature of 1550° F. maintained for 50 hours. Cooling time, 48 hours: 30 hours to 1390° F., 12 hours to 1250° F. and 6 hours to 500° F.

All of the specimens in this experiment showed: Edge: ferrite. Center: ferrite and temper carbon.

Experiment No. 16. Heat Treatment Data.

Hours	2	5	22	28	40	50	71	85	93
Temperature	1100	1550	1560	1530	1560	1550	1570	1390	520

Annealing temperature of 1550° F. maintained for 50 hours. Time of cooling, 40 hours: 30 hours to 1390° F., 1 hour to 1250° F. and 9 hours to 500° F.

No. 99. Packed in bone black in special box. Edge: almost pure carbide, and pearlite. Center: pearlite.

The rest of the specimens showed the same general structure as follows: Edge: ferrite and pearlite. Center: temper carbon; ferrite and pearlite.

It was early noticed that the rate of cooling had an important effect upon the malleableizing process. By referring to the first series of experiments, it will be seen that experiment No. 1 gave the best results. In this experiment, the time of cooling to 1400° F. and 1250° F. was much longer than for No. 2 and No. 3. In experiments No. 2 and No. 3, the interior structure was found to be composed of ferrite, temper carbon and pearlite, showing that rapid cooling tends to from a steely structure. This fact is also shown in experiment No 11 where the furnace failed and the charge cooled very rapidly; the resulting interior structure was like a high carbon steel.

Experiment No. 12 shows that a good malleable structure was obtained only for those specimens at the center of the furnace. Experiment No. 15 shows that a good structure was obtained for all specimens. In both of these experiments the

total time of cooling was practically the same, but the time of cooling from the annealing temperature to 1250° F. was much longer for No. 15 than for No. 12. This fact tends to show that the rate of cooling should be slow down to about 1250° F., after which it may become rapid without endangering the malleable structure.

As the result of this series of experiments, the time of cooling will be taken as 48 hours, divided about as follows: 30 hours to 1390° F.; 10 to 12 hours from 1390° to 1250° F.; and 6 to 8 hours from 1250° to 500° F. The point 1250° F. was taken because it is about 25° below the A r_1 point on the Roozeboom diagram. This point is the critical temperature at which the solid solution of iron carbide breaks down into its constituents of ferrite and cementite, and is known as pearlite.

The Effects of Different Periods of Annealing.

Experiment No. 17.

No. 106. Packed in bone black in special box.
No. 107. Packed in scale in special box.
No. 108. Packed in fine fire clay.
No. 109. Packed in scale.
No. 110. No packing.

Experiment No. 18.

No. 111. Packed in scale.
No. 112. Packed in fine fire clay.
No. 113. Packed in scale in special box.
No. 114. Packed in bone black containing $BaCO_3$ (special).
No. 115. No packing.
No. 116. Packed in bone black.

Experiment No. 19.

No. 117. Packed in scale.
No. 118. Packed in fine fire clay.
No. 119. Packed in bone black containing $BaCO_3$, in special box.
No. 120. Packed in bone black.
No. 121. Packed in cupric oxide. Oxide was all reduced to metallic copper.
No. 122. No packing.
No. 123a. Packed in a mixture of bone black, chromite and barium carbonate.

Experiment No. 20.

No. 123. Packed in bone black containing barium carbonate, in special box.

No. 124. Packed in fine fire clay, special.

No. 125. Packed in scale.

No. 126. Packed in fine fire clay.

No. 127. No packing.

Experiment No. 21.

No. 128. Packed in cupric oxide.

No. 129. Packed in fine fire clay.

No. 130. Packed in scale.

No. 131. No packing.

Experiment No. 22.

No. 132. Packed in fine fire clay.

No. 133. Packed in scale.

No. 134. No packing.

Experiment No. 23.

No. 135. Packed in scale.

No. 136. Packed in fine fire clay.

No. 137. Packed in cupric oxide in ordinary manner; the oxide was not reduced to metallic copper.

Experiment No. 17. Heat Treatment Data.

Hours	2	3	20	27	35	49	60	70	89	94
Temperature	1200	1470	1560	1520	1590	1470	1400	1390	1310	510

Annealing temperature of 1500° to 1600° F. maintained 43 hours. Time of cooling, 35 hours: 23 hours to 1390° F. and 12 hours to 1250° F.

No. 106. Packed in bone black in special box. Edge: very high carbon steel (good eutectoid). Center: temper carbon, ferrite and pearlite.

The rest of the specimens were as follows: Edge: ferrite. Center: temper carbon, ferrite and pearlite.

Experiment No. 18. Heat Treatment Data.

Hours	2	7	15	25	33	48	56	70	75
Temperature	1450	1600	1600	1540	1660	1410	1410	1350	510

Annealing temperature of 1550° to 1600° F. maintained 30 hours. Time of cooling to 1250° F., 30 hours.

No. 114. Packed in bone black and barium carbonate. Edge: cementite. Center: ferrite; temper carbon and a little carbide.

NOTE.—The rest of the specimen had an edge of ferrite and an interior of ferrite, temper carbon and a little carbide.

Experiment No. 19. Heat Treatment Data.

Hours	1	3	20	22	40	52	70	81
Temperature	1430	1600	1630	1520	1500	1420	1360	510

Annealing temperature of 1500° to 1600° F. maintained for 38 hours. Cooling time, 30 hours to 1390° F. and 3 hours to 1250° F.

All of the specimens in this experiment had a rim of either ferrite or a mixture of ferrite and pearlite; the interior structure was composed of temper carbon, ferrite and cementite.

Experiment No. 20. Heat Treatment Data.

Hours	3	5	17	29	33	53	65	70
Temperature	1330	1620	1620	1570	1410	1390	1250	500

Annealing temperature of 1600° F. maintained 18 hours. Cooling time, 30 hours to 1390° F. and 12 hours to 1250° F.

All of the specimens in this experiment showed the following structure: Edge: pearlite. Center: pearlite and cementite.

Experiment No. 21. Heat Treatment Data.

Hours	1	2	10	13	27	40	50	62	74	82
Temperature	820	1600	1650	1620	1620	1420	1420	1270	700	600

Annealing temperature of 1600° F. maintained for 24 hours. Cooling time, 30 hours to 1390° F. and 12 hours to 1250° F.

All specimens had the following structure: Edge: ferrite and pearlite. Center: ferrite, cementite and pearlite.

Experiment No. 22. Heat Treatment Data.

Hours	1	5	20	25	28	31	38	47	70	75	82
Temperature	1150	1530	1730	1210	1580	1610	1600	1420	1350	1250	510

Annealing temperature of 1600° F. maintained for 30 hours. Cooling time, 30 hours to 1390° F. and 10 hours to 1250° F.

All specimens had a good structure as follows: Edge: ferrite. Center: temper carbon and ferrite.

Experiment No. 23. Heat Treatment Data.

Hours	2	3	17	38	67	73
Temperature	1000	1600	1650	1500	1330	510

Annealing temperature of 1600° F. maintained for 30 hours. Cooling time, 26 hours to 1390° F. and 9 hours to 1250° F.

All the specimens had the following structure: Edge: thin layer of ferrite and pearlite. Center: temper carbon, ferrite and cementite.

This series of experiments shows that a malleable structure may be obtained in 36 hours, using a temperature of 1500° to 1650° F.; although 42 hours would be a safer period to use.

It is evident that a high temperature cuts down the time of heating as shown in experiment No. 22; and an experiment conducted outside of this series showed that it was possible to get a malleable structure in 18 hours when an annealing temperature of 1800° F. was used.

The conclusion reached is that a temperature of 1600° to 1650° F. is the best temperature to use, inasmuch as it is neither too low nor too high to endanger malleableization. Be it understood, however, that this conclusion related only to the annealing of small specimens in a small annealing furnace in which the temperature changes are altogether different than in a regular annealing oven of works practice. A temperature of 1800° F. would soon end the usefulness of the saggers and so increase the cost of production that competition with the long time low temperature process—in which a maximum of 1350° F. is kept for 60 hours or even less—would be out of question. Even the 1600° to 1650° F. temperature is safe only for cupola iron, and would ruin furnace iron if continued for the regular time.

An Experiment Showing what Becomes of the Carbon at the Surface of White Cast Iron During the Process of Producing Malleable Iron.

The question of the disappearance of the carbon, or the decarbonization of the rim (skin effect) of malleable iron, has been a much discussed one. It is held by some that the carbon migrates to the interior and remains in the casting, while others claim that the carbon migrates out and disappears entirely from the casting. It is obvious that if the carbon migrates out and leaves the iron at the temperature used for annealing, it must do so in the form of a carbonaceous gas. Hence, an analysis of the gases evolved by the iron during the malleableizing process, using no packing material, would report their exact composition and reveal the presence or absence of carbonaceous gases. From data of this kind, the method of decarbonization could be more definitely shown.

In this connection, the following preliminary experiment was performed. A piece of white iron was annealed in cupric oxide, the idea being to detect the presence of CO by noticing the degree of reduction of the oxide. The result of this experiment showed an extended and complete reduction of the oxide to metallic copper, but inasmuch as some reduction of the cupric oxide would occur anyhow, due to the higher heat of formation of the oxide of iron over that of copper, no definite conclusions could be drawn from the result of this experiment.

The final proof of the presence of a carbonaceous gas was therefore made by collecting the gas coming off from the specimen during the annealing period, and analyzing it according to the Hempel method.

Apparatus.—1. A piece of white iron 1 in. square and 6 ins. long, weighing 700 grams, used as the specimen.

2. A closed container to hold above, consisting of a 1½ in. x 5 in. nipple, with an iron cap for one end, and reduced to a ¼ in. pipe at the other.

3. A piece of ¼ in. pipe and connections for leading gas from container to sampling tubes.

4. Glass gas sampling tubes filled with water saturated with carbon dioxide.

5. Mercury burette for gas sampling.

6. Filter pump and connections for exhausting air from container and pipes.

Method.—The container and iron piping were first thoroughly cleaned to remove any dirt or grease, and the inside of the container was given a thin coat of fire clay. Next, the specimen was placed inside of the container, and after having been tightly screwed together, the outside of the container was given a very heavy coating of fire clay. The container was then placed in the furnace with the outlet pipe leading through a hole in the door; and the heat started. After the furnace had been heated to 1600° F. for several hours, suction was applied to the outlet pipe of the container and the air exhausted for several minutes. Samples No. 1 and No. 2 were then taken.

Sample No. 1 was collected in a glass sampling bottle over water saturated with carbon dioxide. The gas came over at the rate of about twenty bubbles per minute, with the sampling

bottle lying flat and the departing water creating no suction. There was sufficient gas pressure to fill the bottle when the exit of the tube was raised higher than the entrance.

Sample No. 2 was collected over mercury shortly after No. 1 was taken.

Sample No. 3 was collected after the furnace had been up to 1600° F. for 6 hours, and up to 1800° F. for half an hour. The gas came over at a rapid rate and was under considerable pressure.

Sample No. 1. Collected over Water.

	Per cent.
Carbon dioxide	13.2
Hydrocarbons	0.0
Oxygen	8.8
Carbon monoxide	21.4
By difference, N	56.6

Sample No. 2. Collected over Mercury.

	Per cent.
Carbon dioxide	13.2
Hydrocarbons	0.0
Oxygen	8.8
Carbon monoxide	26.8
By difference, N	51.2

Sample No. 3. Collected over Water, Furnace at 1800° F.

	Per cent.
Carbon dioxide	4.6
Hydrocarbons	0.0
Oxygen	3.4
Carbon monoxide	71.2
By difference, N	20.2

Attention is called to the very high percentage of carbon monoxide and the corresponding low percentages of oxygen and carbon dioxide.

From the results obtained in this experiment, the proof of the carbon leaving the casting in the form of a carbonaceous gas is indicated.

Both Samples No. 1 and No. 2 show this fact in their analyses, and are checked. The analysis of Sample No. 3 shows the presence of a very high percentage of carbon monoxide and a corresponding decrease in the amounts of oxygen and carbon

dioxide. This is probably due to the fact that No. 3 was collected at a much faster rate and when the furnace was considerably hotter than for No. 1 and No. 2.

General Conclusions.

1. The nature of the packing does not affect the interior structure of the iron; while the surface or "skin" effect may vary from pure ferrite to a pearlitic structure.

2. Packings like rolling mill scale and fire clay give as good results as any and have the added advantage of being cheap. Of these two packings, fire clay would be the better because it packs closer and more effectively prevents access of the oxygen of the air to the specimen or casting.

3. Castings may be malleableized without the use of any packing, but a good muffle furnace should be used to keep down the oxidation of the surface of the castings.

4. Air-tight containers or those as nearly so as possible should be used to keep down oxidation effects.

5. A temperature of 1550° to 1650° F. has proven to be best temperature to use for iron of the analysis previously given and under the conditions tested. This range insures a complete breaking down of the carbide.

6. A temperature below 1400° F. did not cause a complete breaking down of the carbide structure; and even prolonged heating would not have produced a malleable structure when as low as 1000° F.

7. At temperatures of 1400° to 1500° F. there is danger in not getting a good malleable structure in those castings farthest from the source of heat and the oven walls.

8. The above conclusions are understood to be based upon annealing small specimens in small ovens, in which temperature variations are more marked than in the large, almost uniformly heated ovens of commercial work.

9. The time of cooling from the annealing temperature to 1200° F. is the most important variable in the process.

10. A rapid rate of cooling, even when sufficient heat and time of annealing is used, forms a pearlitic or "steely" structure.

11. The time of cooling to 1250° F. should be about 42

hours. The cooling below this temperature may be rapid and not materially affect the malleable structure.

12. A period of from 36 to 42 hours gave the best results for this range of temperature.

13. An experiment not herein recorded showed that a good malleable structure could be obtained in 20 hours, using a temperature of annealing of 1800° F.

14. The period of annealing is entirely dependent upon the temperature of annealing and the type of furnace used.

LIST OF ILLUSTRATIONS.

All Micrographs Enlarged 100 Diameters, and Etched with Picric Acid.

Fig. 5. Shows good interior structure of ferrite and temper carbon.

Fig. 6. Shows rim of pure ferrite.

Fig. 7. Shows an edge composed of ferrite and pearlite. (Steel.)

Fig. 8. Shows an interior structure of ferrite, temper carbon and pearlite.

Fig. 9. Shows an edge carbonized; bone black used as a packing material.

Fig. 10. Shows an interior structure of ferrite, temper carbon and traces of carbide.

Fig. 11. Shows an interior white iron structure which is partially broken down.

Fig. 12. Shows an edge of steel—pearlitic structure.

Fig. 13. Shows interior of ferrite, temper carbon and pearlite.

Fig. 14. Shows an edge of very high carbon steel.

Fig. 15. Shows peculiar structure of double steel layer.

Fig. 16. Shows a heavy layer of ferrite and then pearlite.

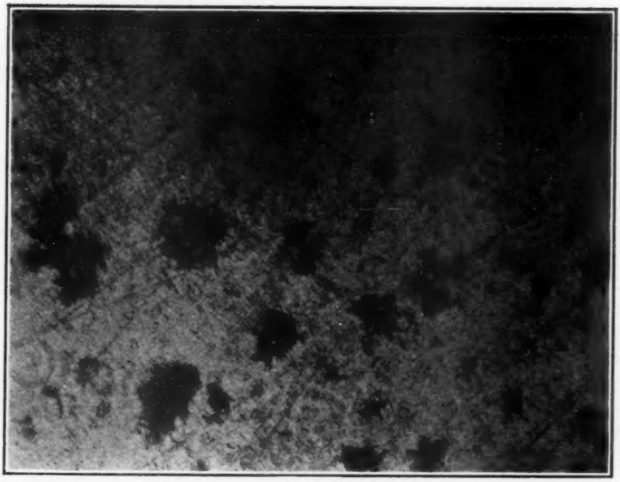


FIG. 5.

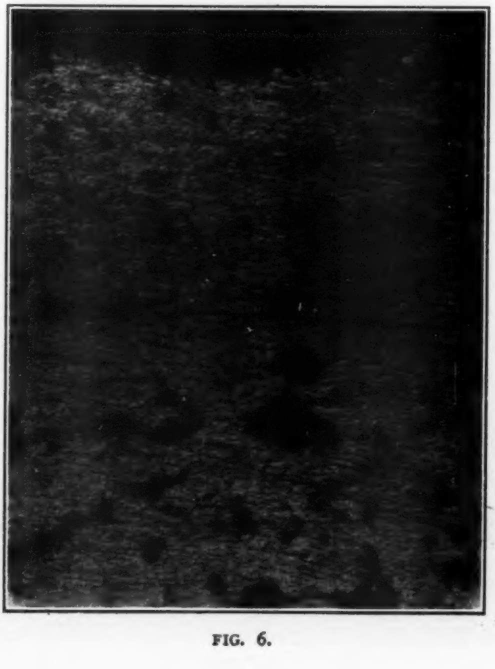


FIG. 6.

FIG. 7.

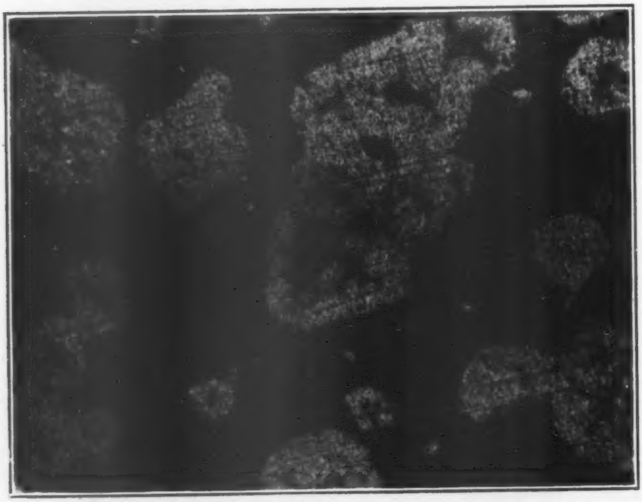


FIG. 8.

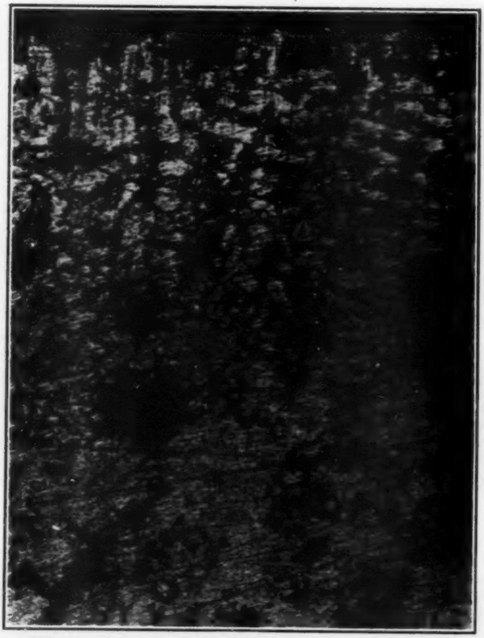


FIG. 9.

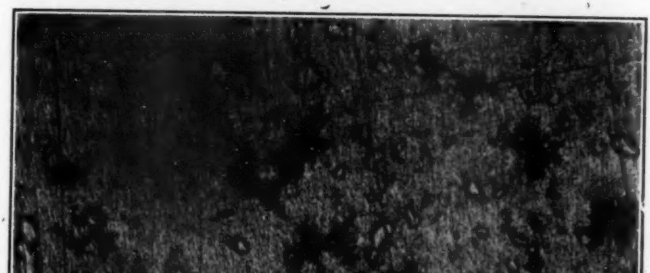


FIG. 10.

FIG. 11.

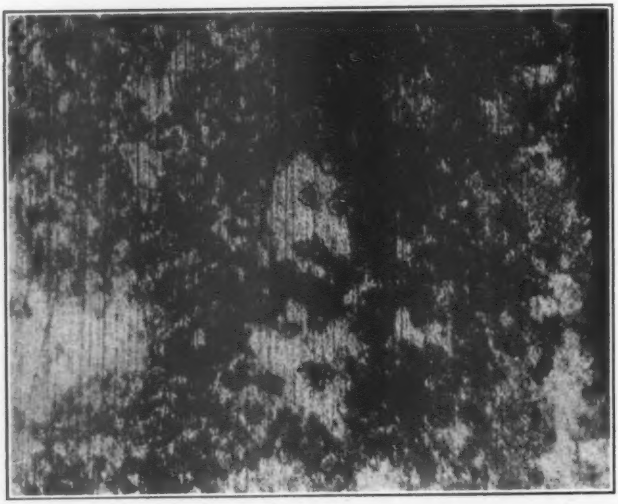


FIG. 12.

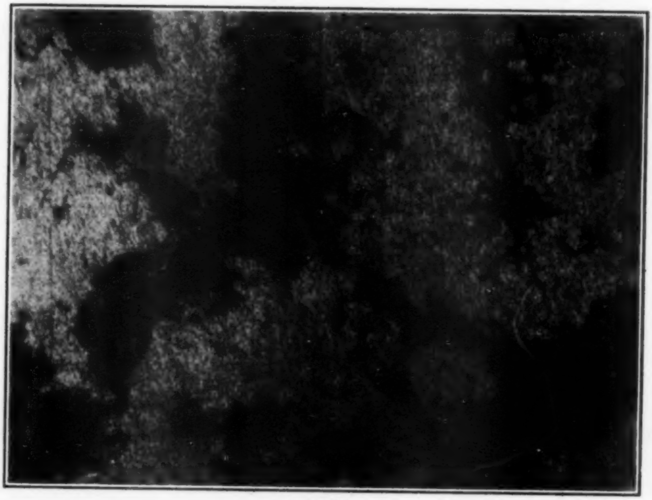


FIG. 13.

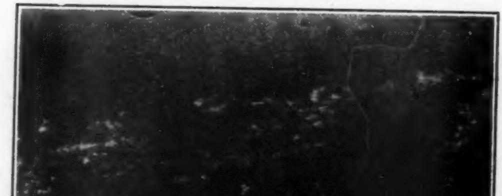


FIG. 14.

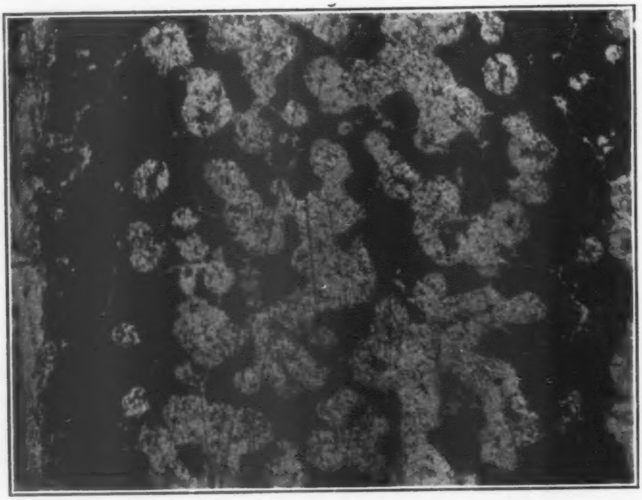


FIG. 15.

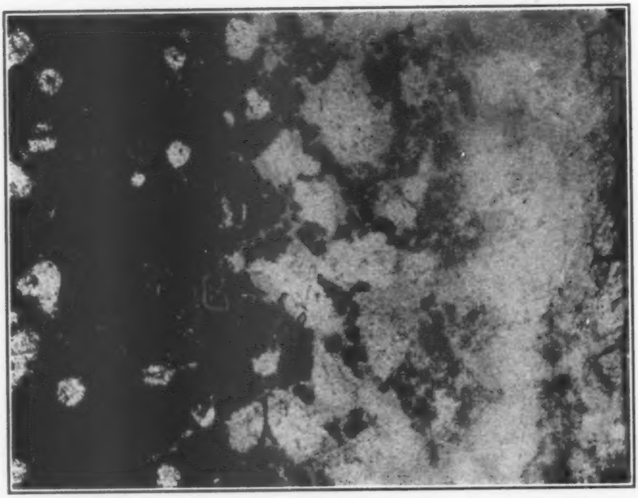


FIG. 16.

ON THE INFLUENCE OF CHANGING THE COMPOSITION OF MALLEABLE CASTINGS.

By P. Rodigin, Berdiansk (Sea of Azov), Russia.

In order that a proper conception may be had of the influence of metal and alloy additions to malleable castings (black-heart), it is necessary to assume that in the annealing process the material is in a fluid or semi-fluid state (so far as the mobility of the molecules are concerned). The precipitation of graphite at the moment of set from liquid gray iron, thus finds its counterpart in the formation of temper carbon in the malleable casting. Similarly can one understand the relation of graphite to the other elements in cast iron as compared with the temper carbon in the malleable casting. So far as physical effects are concerned, these are comparable in a measure, as for instance the hardening effect of manganese, sulphur, etc., though the percentages prevalent are different.

I have instituted a number of tests on the effect of adding diverse elements to malleable cast iron, in order to study the resulting chemical and physical properties.

Manganese.—Adding this element promotes the separation of temper carbon in the annealing process. I do not subscribe to the opinion of Ledebur and other well-known experts who hold that manganese prevents graphite formation. Only in the case of large percentages is this the case. However, I have noticed that the strength of malleable castings suffers considerable with the higher manganese ranges, as graphite is separated out, and shrinkage cracks become more marked. Rapid cooling of the material after anneal results in a recombination of the temper carbon, and the fracture exhibits a silken white appearance. Manganese increases the fluidity of the metal.

Silicon.—Increasing this hastens the annealing process. The strength is reduced, but in not so great a measure as through high manganese. It also increases fluidity.

Aluminum.—Hastens annealing. Reduces strength. In large amounts gives porous work, as deoxidation with formation of gases continues up to the moment of set. Reduces fluidity of molten metal.

A rather interesting occurrence was noticed in connection with the addition of comparatively large percentages of aluminum, and that was the separation of graphite in sufficient quantity to give a gray fracture—thus confirming the observations of other experimenters. The peculiar situation, however, was that the annealed samples turned out to be pretty good malleable, the fracture being very black from the additional temper carbon formed as the result of the heat treatment given. The annealing was done in a remarkably rapid time, only a few hours being required.

Titanium.—This accelerates the annealing process.

Antimony and Tin.—Additions of these metals make the castings brittle, as well as damaging the fluidity.

Copper.—Retards the annealing process materially, and renders the metal less fluid.

Bismuth and Lead.—Fluidity affected badly, but otherwise have no effect on the time of anneal.

Sulphur and Phosphorus.—The following tests were made: To the same molten metal, containing Si. 1.10, Mn. 0.46, P. 0.100, and S. 0.07, and when annealed giving 2.20 temper carbon (presumably by boring right through the casting and taking all the chips), there was added in one ladle some sulphur, and in another some phosphorus. Castings were then made from both and annealed under identical oven and heating conditions. The S. sample had the temper carbon drop to 1.4 after anneal, the sulphur being 0.23. The P. sample had 2.1 temper carbon, with the P. 0.19.

My observations indicate that as the sulphur rises annealing becomes more difficult (for black-heart), and when quite high, the material will not anneal at all. Even when annealed, the fracture is not fine black and the castings are not strong. The castings are, moreover, difficult to pour, as the metal will not remain fluid long enough, and unless cooled very carefully after the anneal, any chilling action is liable to make the fracture

white again. Sulphur is the dangerous element the founder has to contend with.

Phosphorus retards the annealing action, requiring more time as a consequence, and when in comparatively large amounts weakens the material.

In the hope that these observations may interest American producers of malleable castings, and that similar tests be made with metal and alloy additions to extend our knowledge on the subject, these memoranda are respectfully presented to the American Foundrymen's Association.

IRON—WHERE DOES IT ALL GO?

By D. C. Wilson, Newark, N. J.

A Contribution from the Associated Foundry Foremen.

Iron is not a new material to man. History speaks of it from the earliest times as used in war and peace. Turning to the sacred pages of the Scriptures, iron will be found as having been wrought by Tubal Cain, who was an instructor of artificers in brass and iron (Genesis 4 : 22). Then again in Numbers 31 : 22 we find a list of metals given: brass, iron, tin and lead. And again in Numbers 35 : 16 we see it as being made into an instrument to slay with. Deuteronomy 3 : 11 records an iron bed for a giant king—so that iron beds are not new. In 4:20 the Israelites are spoken of as coming from an iron furnace, indicating that some form of a furnace must have been known then. In Joshua 17 : 16–18 we note that the Canaanites made use of iron for their chariots, whereas the giant Goliath of Gath was heavily coated with brass and iron. His spear's head weighed 600 shekels of iron (I Samuel 17 : 7).

As we go through the records of Biblical times, we note that harrows, axes, saws, pruning hooks, spears, threshing instruments and even iron pens were in vogue, and no doubt the familiar dream of Nebuchadnezzar mentioned in Daniel 2, in which a figure is described, having legs of iron, and feet of iron and clay, will be recalled. The museums are full of the remains of ancient iron weapons, and as we pass down the eras of history we note that iron is constantly spreading in use, and from being an element of destruction has been gradually harnessed to the uses of mankind. The sword became the plowshare, and coats of mail have been discarded. Just the same, however, the old flintlock has been replaced by a deadlier weapon of iron, and iron battleships dot the earth in many places.

As we leave the fiercer aspects of the uses of iron, we come to a great list of adaptations which have played a most important feature in the advance of civilization. First, the printing press and the revolution this brought about in thought and times. Other machines, in modern times such as those for planting and reaping. Machinery for the making of iron itself from its ores and even the winning of these ores. From the rock drill to the railroad, the blast furnace and steel mill, the foundry, and finally to home or manufactory—only to get into the scrap heap for a repetition of the last part of the previously mentioned cycle. Millions of articles are made of iron and used every day in office, factory and home. One need only think of the fine hair-spring of the miniature watch, and compare with the ponderous battleship to note what a marvelous development is this our civilization.

In our cities we see huge masses of steel in the giant structures high above the earth. Masses of iron in the dynamos and engines, elevators and the like. Miles of iron pipe carrying water. All the delicate manipulation through fittings and valves to bring this water to every point wanted for our comfort. Even in the foundry the salamander is a welcome friend in cold days, whereas what can replace so easily the heating system of our homes. Iron in everything.

Now that we recall the foundry, we see what strides have been made in the use of molten iron. In a shop in the East a jarring machine has made molds, the flask and sand weight being no less than twenty tons. The molding machinery, core apparatus, ladles, cupola, blowing and elevating machinery, pig iron, almost everything is of iron. What interests us specially is that all iron can be made use of. Whether it is correct to say that "all iron is good iron," or what we sometimes feel, that "all iron is bad iron," is not so important, but it is the art to take iron as we get it into the cupola and to make good castings therefrom.

It is the study of this great subject, so far as it concerns the foundryman, that the gatherings of foremen in all parts of the country are interested in. Whether the cupola, molding, coremaking, the pattern shop or any other matter comes up, discussion is had and those present learn something. The more the foundry foreman discusses the troubles he has to contend with and exchanges points of practice, the more useful he will be to his

employer and the better will be the castings he makes. Hence he should strive to learn all he can by helping the movement for the advancement of knowledge. To make a pound of iron go further, to make the maximum of good work, to help educate the molders to a higher standard of efficiency; all this serves to extend still further the usefulness of the wonderful metal iron, without which civilization would not be today where it is.

MEMORANDA ON AUTOMOBILE CYLINDER FOUNDING.

By Robert Crawford, Detroit, Mich.

Very few designers of automobile engines for gasolene give the foundry end of the work any consideration, and hence it is quite common to have light and heavy sections cast together. At times this could easily be avoided, yet often not. The consequence is that chills are used, which is a practice I am not in favor of. I would much prefer to change the design where possible, and for the rest rely upon careful cupola practice for this class of work.

The first thing to watch is naturally the cupola. With all the difficulties the foundryman has to contend in his melting practice, there is really nothing simpler than the cupola, and the results are absolutely safe if he know the principles underlying its proper operation. He may buy the best of pig iron and scrap, but unless this material is melted right, the results will be defective in the qualities wanted. Iron will be hot and dull in turns, the coke will get the blame, and the men most interested await the heat with constant dread.

The proportions in the cupola must be properly observed. There is only one given volume of air that operates to the best advantage for every cupola diameter. It is not the blast pressure that counts, but the blast volume. If through too much air, and consequent high blast pressure for the same charging method and material, the lining is cut out badly, this should be looked after. Linings cost money, and a good blast arrangement should mean relining only once a year.

Next, by using small charges and with a proper bed thickness, there is no reason for pin holes or internal shrinkage in the work you make. It is a great mistake to work for a high melting ratio. Some men make it one to ten and others one to eight. There is but one correct ratio for each cupola and method of running

to give good hot iron free from trouble-making characteristics, and when this is found, it should be held until the coke or melting stock is changed.

The importance of iron free from pin holes and shrinkage for automobile cylinder work cannot be over-rated. Those who save coke and hence melt down too low in the melting zone will realize this when they run across such castings as a piston, for instance, which may have passed through every operation up to the drilling of the hole for the wrist-pin. The inspector finds what he calls a sand hole. Study it closely and you will find it to be the result of gas in the iron. The metal has been burned in the cupola.

Another point is the great advantage of prevention as against cure. It is far better to melt right than to attempt to correct a ladle full of iron with alloys. The latter, in deoxidizing the metal, also chills it sufficiently to hold the dross and oxides formed in suspension until set, thus defeating the very object of the process.

When the cupola is kept in blast longer than two hours, it is essential that it be slagged off. Limestone of good quality cannot be excelled for this purpose. For ordinary run of melting stock about fifteen pounds to every thousand of metal is all I use. With proper charging methods there will be little bridging of the cupola, and hence no serious damage to the lining from the chipping necessary after a heat.

It goes without saying, that for automobile cylinder work the pig iron piles should be under control as to chemical composition. You should know what your daily product analyzes, and you should further train your eye, that with a knowledge of the analysis you can note from your fractures if anything "off" is apparent. For this class of work—and I make the several parts for about fifty automobile and marine engine manufacturers—the iron should have as little shrinkage as possible, possess great durability, and show good machining qualities. I make hard iron just as every one else does at times, but when a "kick" is registered I investigate and straighten the matter out as rapidly as I can.

The unfortunate situation in the automobile industry is that the purchasing agent looks for cheap castings, and the foundryman simply has to use a lot of scrap of which he knows little or nothing. The result is a wailing in the machine shop which is not good to hear. Those who know will not be bluffed

into this way of doing business. They will use the best of materials and charge their price. Not only has the temptation to quote a low price and then make up by using cheap scrap caused much disaster, but the advent of the automobile engineer has given us $\frac{5}{32}$ in. and $\frac{3}{16}$ in. water jackets, where $\frac{7}{32}$ in. and $\frac{1}{4}$ in. had been the rule. The great strain from vibration and the gas explosions put on the cylinders, pistons and rings has proven conclusively that it is wise to start with a good foundation in the way of raw materials, and then to melt them right.

As to the use of charcoal irons for this class of work—being nearer to the charcoal iron market than our Eastern foundrymen—I will say that from the nature of its making, it is purer, wears better, is a close iron which will polish like steel and not cut piston or rings. On account of the expense it is necessary to mix with coke irons, but in doing so while making the mixture see that the composition corresponds to the design. Melt hot and pour hot. If the metal cuts the mold, face this with material that will stand hot iron. Hot iron always gives a better casting than dull iron.

I trust that with these few points brought out, there will be a discussion on the subject which will result in further information, for the possibilities are great since the troubles are many and varied.

AMERICAN FOUNDRYMEN'S ASSOCIATION.

ON THE RELATIVE VALUE OF FOUNDRY FLOUR WITH SIMPLE METHODS OF TESTING.

By G. S. Evans, Lenoir City, Tenn.

Since the establishment of a chemical laboratory and test department at the Lenoir Car Works some three years ago, of which the writer was fortunate to be placed in charge, besides the routine work incident to the control of the cupola mixtures and research work, some attention has been devoted to thorough testing of all classes of materials entering into the foundry routine, with a view to determining the most economical materials. Each class of supplies was taken up in the order of its importance in the foundry. This short paper is a summary of the tests on foundry flours, and with it the specifications for this material, prepared as the result of the investigation.

It might be well to state here that the preliminary investigations demonstrated the superiority of flour for our purposes over any of the core compounds tested, and therefore our further attention was devoted exclusively to testing different brands and grades of flour.

In order that you may more fully understand the specifications printed as a part of this paper, I will first outline the properties of the different constituents of the wheat berry and its milled products. The wheat berry from the miller's point of view is composed: first, of an inner and outer skin, made up largely of woody fiber containing small percentages of mineral matter; second, starch granules inmeshed in a network of gluten; third, germ or heart, containing relatively large percentages of protein fatty substances; fourth, placenta, containing relatively large percentages of mineral matter, or ash.

Of the above starch and gluten are the only constituents possessing any marked power of adhesion and thereby being of value as core binders. Of the two, gluten is by far the most valuable.

Starch is a fairly stable substance at ordinary temperatures, while gluten is subject to rapid decomposition, especially when subjected to extreme atmospheric conditions. It then loses its tenacity or binding property. This decomposition is indicated by a musty odor, and such flours should be avoided for foundry as well as domestic purposes.

In the milling process the greater part of the inner and outer skin, to which adhere small parts of starch and minute traces of gluten, are separated as bran, which is of no value as a core binder. The remainder of the inner and outer skin, the germ and the placenta, to which adhere large quantities of starch and gluten, are separated in one or more grades as "Shorts" or offal flour, the finer grades of which are often sold as foundry flour. The remaining portions of the wheat berry—starch and gluten, along with traces of all of the foregoing constituents—go to make the true flours, commonly termed starch or gluten flour, and as the names imply are high both in starch and gluten.

The offal are distinguished from the starchy flours by the presence of bran particles or, if reground, by their yellowish color and mealy and somewhat oily feeling, and on analysis by the relatively high percentages of crude fiber, crude fats and ash or mineral matter they contain.

Since starch and gluten are the only two constituents of wheat possessing the power of adhesion, and therefore of value as a core-binder, it is evident that those flours containing the greatest amount of these two constituents should be the most efficient (and I would say here that tests have shown these to be also the most economical core binders), and further, that the binding power of a flour should be directly proportional to the percentages of these constituents. The latter, however, does not hold true for the offal flours, owing to the fact that a large part of the starch and some of the gluten remains attached to the bran particles and is therefore not available for cohesion of the sand particles.

Having determined the foregoing facts, specifications were prepared for foundry flour, a copy of these being shown in Table I. In preparing the specifications it was endeavored to fix the maximum and minimum of the several constituents so as to allow of purchasing the lowest grades of starchy or gluten flours produced

in ordinary milling practice—allowing for the wide variations in wheat from different agricultural sections—but which would exclude offal or adulterated flours.

Table I.—Lenoir Car Works. Specification No. 13 A.
Foundry Flour.

The material desired under this specification is starchy wheat flour, free from all adulterants either vegetable or mineral, and must conform to the following detail specifications:

1. Physical properties should show a smooth surface, free from any appreciable amount of visible bran particles, when slicked-out with a smooth paddle or spatula and examined with the naked eye at a distance of fifteen inches from the slicked surface. Must be free from musty odors.

2. Chemical Composition—

Mineral matter or ash must not exceed..........	1.35 per cent
Crude fat or ether extract must not exceed......	2.50 per cent
Crude fiber must not exceed...................	1.25 per cent

3. Each car load shall be considered a unit. Samples of one pound each will be taken from each 5,000 lbs. of the shipment, the samples added together and thoroughly mixed and the resultant sample represent the shipment.

4. The chemical composition will be determined according to standard methods, and should the sample fail to meet the above requirements, the shipment will be rejected.

5. All rejected material will be held subject to shipper's disposition and the shipper shall assume all charges on rejected material.

6. All shipment to be made in jute bags unless otherwise specified.

G. S. Evans,
Chemist.

Approved: B. F. Lively, *Manager,*
Lenoir City, Tenn.
September 16, 1913.

In Table II are given the analyses of twelve samples of foundry flour; of these samples 1–5 are low-grade starchy flours complying with the specifications, all of which have proven very satisfactory in the core room, samples 6 and 7 are offal flours, and 8–12 adulterated flours, none of which pass the specifications.

The flours represented by analyses number 6 and 7 were each used over a period of two weeks for making the ring cores (350 cores per day) for 33 in. cast iron car wheels and were found to require an increase of 25 and 31 per cent respectively over the amount required in the case of samples 1–5 to do the same work.

On comparing the base prices of the twelve different flours

shown in the right-hand column of the table it will be noted that the two samples of offal flours are listed even higher than some of the starchy flours complying with the specifications, and further, that the prices of the adulterated flours far exceed their actual binding value when compared with the higher grade flours.

Experience has convinced us of the necessity of the specifications, and we have found it perfectly possible to obtain flour upon the specifications at approximately the same price that we would have paid for offal flours. The foundries in the United States using flour as a core binder should discontinue the use of offal and adulterated flours—and I mean to infer that the majority of the foundries using flour are using inferior or adulterated products

TABLE II.—CHEMICAL ANALYSES. FOUNDRY FLOURS.

Sample.	Moisture, per cent.	Carbo-hydrates, per cent.	Mineral matter, per cent.	Protein, per cent.	Crude fiber, per cent.	Crude fats, per cent.	Base price, per 100 lbs.
1	10.90	73.76	0.63	12.04	0.69	1.98	$1.79
2	11.96	71.73	0.41	12.85	0.86	2.19	1.94
3	10.31	72.76	0.96	13.10	0.57	2.30	1.83
4	12.20	71.62	0.74	12.74	1.14	1.56	1.77
5	11.83	74.12	0.61	10.80	0.39	2.25	2.00
6	10.57	65.70	2.19	15.22	1.56	4.76	1.81
7	9.58	65.14	1.28	16.03	3.78	4.19	1.80
8	6.58	47.87	34.28	8.33	0.88	2.06	1.74
9	6.09	54.78	30.16	6.42	0.71	1.84	1.70
10	5.17	48.46	37.12	6.47	1.19	1.59	1.60
11	5.81	42.43	43.08	5.82	1.11	1.75	1.50
12	4.97	40.04	45.60	6.01	0.97	2.41	.....

and substantiate this inference first, by a personal canvass of foundries; and second, by the fact that all of the samples furnished us by the leading foundry supply houses in the United States were either of inferior grade or were otherwise adulterated by the addition of 30 per cent or more of mineral matter. If foundries would use low-grade starchy flour, it would in time affect a general saving of 25 per cent of the present cost of this material.

In testing the binding power of the different samples shown in Table II, there were made up two batches of sand of each of the twelve samples, using for one batch a mixture of 1 part of flour to 30 parts of sand, for the other 1 part of flour to 60 parts of sand, tempering each batch with four parts of water. A medium fine silica sand was used in the tests—this was thoroughly air dried

before using and the water was carefully added so that each batch or mixture would be tempered alike. Four cores $1\frac{1}{2}$ in. square by 10 in. length were made from each batch, dried at a constant temperature and broken with a distance of 8 in. between supports.

Fig. 1 shows a cut of the apparatus used for breaking the cores, with a core in position ready for breaking. This is made of wood and as you will note is of simple construction and can be quickly made. The core to be tested is placed on supports D E, spaced apart at a distance of eight inches, and the lever lowered so that knife-edge B rests on the core—this is spaced one-third of the distance between A C and arranged so as to rest on the core half-way between supports D E; bird shot are carefully run into the bucket until the core fails, after which the bucket is removed

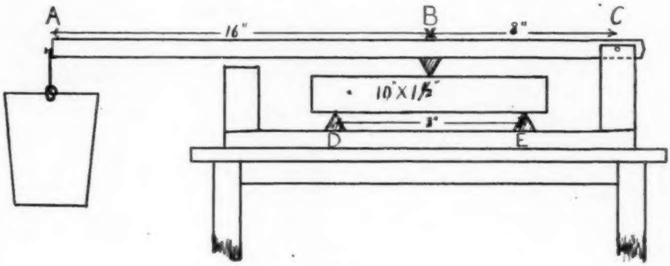


FIG. 1.

and weighed; this weight multiplied by two gives the strain exerted upon the core or transverse strength in pounds and decimals thereof.

As stated above, four cores were tested from each of two mixtures of the twelve samples shown in Table II, and where the discrepancy was great between the results of the individual cores, a second or even a third batch was made and tested, so that an average could be had from four bars that ran in close agreement. The cores of a set run pretty close, even though we made two or three sets of the same mixture on different dates and under different weather conditions in order to determine the constancy of the results under different conditions. Similarly, we usually found the average of two or more sets to run very close, *i. e.*, the averages

of two sets made with flour No. 1 in the proportion of 1 part flour to 30 parts sand were 46.3 and 45.9 lbs. and the same proportions with flour No. 6 were 32.1 and 31.5 lbs.

This method of testing the relative binding power of different flours and core compounds is very simple and has been found very reliable both for the above purpose and for testing the strength of different sands and core mixtures. The results of the transverse tests are given in Table III; in this No. 1, etc., correspond to No. 1, etc., of the analyses.

TABLE III.—TRANSVERSE TESTS.

Test core—1½ x 1½ x 10 in. made flat.
Broken with distance of 8 in. between supports.

Test Number.	Mixture	
	1 part flour. 4 parts water. 30 parts silica sand.	1 part flour. 4 parts water. 60 parts silica sand.
	Broke at lbs.	Broke at lbs.
1	46.1	41.5
2	62.5	44.9
3	53.2	....
4	48.4	39.7
5	57.0	....
6	31.8	28.8
7	39.5	21.9
8	28.8	11.9
9	23.6	17.2
10	25.2	11.3
11	21.5	....
12	24.4	13.0
Average of 1–5	55.24 lbs.	42.13 lbs.
Average of 6–7	35.65 lbs.	25.35 lbs.
Average of 8–12	24.70 lbs.	13.35 lbs.
Average of 6–12	27.83 lbs.	17.35 lbs.

On comparing the results it will be noted: (1) That the average of all cores made with flours passing the specifications show an increase in strength of 95 per cent for the 1–30 mixture, and 143 per cent for the 1–60 mixture, over the average of all cores made with flours failing to pass the specifications. (2) That the cores made with flours passing the specifications show an increase in strength of 55 per cent and 66 per cent, respectively, over the cores made with offal flours Nos. 6 and 7. (3) That the averages of cores made with flours passing the

specifications show an increase in strength of 120 per cent and 216 per cent, respectively, over the averages of cores made with the adulterated flours Nos. 8–12. (4) That generally speaking the flours passing the specifications are worth just two and one-sixth times those failing to pass.

As stated previously, this paper is simply a report of investigations of foundry flour and does not make any pretense at a scientific or comprehensive treatment of the subject. I hope, however, that it will be the means of inducing foundrymen to make further investigations into the relative value of the different classes of materials they use and will tend towards the general elimination of adulterated or inferior grade foundry supplies.

"PUT YOUR HOUSE IN ORDER."

By Frederic A. Parkhurst, M.E., Detroit, Mich.

Up to the present time only a small minority of foundrymen have taken up scientific management to any great extent. This may, perhaps, be due to the fact that the literature on the subject has been devoted almost exclusively to other branches of manufacture. The foundry offers fully as large a field for conservation of materials and human energy as does the steel mill, machine shop, printing house or textile mill.

The foundryman is probably more or less familiar with what is being accomplished through the application of the science of management to trades other than the foundry. He may not realize what the adoption of such principles would mean to his own particular business. In treating this subject the writer confines himself strictly to the practical side of the question based upon his own actual experience, as he believes that the science of management can be most clearly interpreted when so specifically treated. The limits of this paper will not permit much detail, but it is hoped that an interest, commensurate with possible results, may be aroused from the foundryman's point of view.

The preliminaries necessary to getting "your house in order" measure the results you can obtain. There is much to be considered before the detail of reorganization actually commences. This fact is too often overlooked, and partial or entire failure follows, because the foundation did not contain the essential factors. These prerequisites involve both the owner or stockholders upon the one hand, and the organizing engineer upon the other. They may be considered under the following heads: Owners' responsibilities require:

A. An intelligent general knowledge of the science of management in theory and in practice.

B. An acquaintance with plants now running under such principles.

C. A clear perception of their own plant conditions and organization in comparison with the more complex methods based upon the science of management.

D. An understanding of the radical changes which must be made from the established conventions.

E. A thorough investigation into the experience and qualifications of the organizing engineer.

F. An absolute support and recognition of the authority of the organizing engineer, once he assumes his duties.

G. A complete realization of the importance of the controlling factor, "time."

The organizing engineer's responsibilities require:

H. A preliminary inquiry into the business, plant, and owner's relations to same, as well as their conception of the science of management and their ability to see the installation of such carried to completion.

I. A report upon necessary changes which shall incorporate recommendations and the probable improvements to accrue.

J. A study of the personnel and plotting of the organization.

K. A determination upon a method of procedure which shall expedite the reorganization along lines consistent with best permanent results, a minimum cost, and relief of greatest elements of inefficiency as soon as possible.

L. The establishing of a self-sustaining organization, supported by clearly defined ideals, written instructions, automatic reward for efficient work with the personal factor a paramount one.

The above items cover the chief factors which demand serious consideration. Let us discuss them individually.

A. An owner decides in an enthusiastic moment to put his plant under the new science of management. It is not sufficient. Such a decision should only be reached after a knowledge of indisputable facts and much calm reflection. He is making an investment, which, from first to last, will use a goodly amount of money and time. Suppose that he has an established prestige and a profitable business which has been in successful operation for years. He must not jeopardize it for an experiment. Of course, there are many cases where the financial statements of

a company's condition show a profit where quite the reverse is true; but for argument's sake, let us assume that a concern is prosperous and has been "making money" for a majority of the years it has been in existence. That fact does not prove that it is going to continue to do so. Present-day business conditions are rapidly changing. Our old margins of profits are disappearing. New factors are constantly springing up within the field of competition. Today it is a new tariff schedule, tomorrow a wave of unrest in the Labor world. Furthermore, we are getting more and more wasteful. We have enjoyed too much prosperity. Labor gives us less work per hour, paid for at an ever increasing price. Why? We have grown too big to watch the small details. We have grown too fast to take the time to train skilled help. We have lost the personal touch which was the small owner's greatest asset. The destructive result is inefficiency; and it is a germ which continues to grow and multiply until its prevalence ruins a company. Only drastic measures will eliminate it.

The owner must consider his problem dispassionately. He is facing the inevitable if his competitors grasp at the solution first. What is the answer? It can be found by those methods which develop the personal touch, grasp of detail, control of materials, accurate knowledge of all the variables affecting any business and maximum prosperity through high wages for the rank and file.

B. That this answer has been proved can be established by a visit to many plants running under the science of management. There are enough of them to afford ample opportunity for the study of its workings under prevailing manufacturing conditions. They are old, established plants, prosperous before the installation of such methods, but doubly so now. That does not necessarily mean a doubling of the net profits, though such is true in some cases. An increased prosperity is realized through several factors:

(*a*) Greater profits.

(*b*) Satisfied customers, hence more staple and steady source of orders.

(*c*) Less nomadic and better satisfied labor due to higher wages and better shop conditions which results in an absence of labor troubles.

(*d*) Ability to safely and intelligently meet fair competition through efficient manufacturing methods and accurate cost records.

It is hoped that each person interested will verify for himself the conditions existing in plants running under scientific management. A day spent in each, of several so organized, would be of advantage to any owner. Such firms rather invite a study of their conditions. The owner contemplating the adoption of methods founded upon the principles of scientific management, owes to himself and his associates all the advantages that can come from an intelligent study of these methods in actual operation.

C. That you may compare the ordinary foundry with its possibilities under correct methods, let me draw you a picture of a foundry as it actually appears under such methods. The first impression one receives is that no one, from the office boy to the laborer, seems in a hurry, yet each is busy. This is quite contrary to imagined conditions. Though there is no apparent hurry, each one has plenty to do and everything is moving along at a high speed. The individual has specific duties, and his written instructions cover every detail of his work. He makes few false moves. He is paid more than he could get in any shop run under old lines.

There are operations being performed at an unheard of speed. For example, here is a man making 600 cores per day when formerly 150 was a day's production. There are 90 crank cases a day from one pattern that the best foundry and pattern shop talent said could not exceed 40. Castings are poured under pyrometer control, material taken to and from the men. One sees specially trained men, not molders, pouring difficult molds successfully.

The time study men are making analyses of operations on a job and timing each with a stop watch. Do the men object? They did at first, but they receive a bonus of 25 per cent of their wages while they are being timed and they realize that when the correct time has been established they make more money on that job because of the bonus attached.

Now let us look at the indirect elements which are responsible for this production and the smooth running of the shop. Chief

of these is the planning room, or "brains of the shop." The several important functional men employed through and about the shop are:

1. Production clerk.
2. Route clerk.
3. Order-of-work clerk.
4. Schedule clerk.
5. Time study foreman.
6. Material foreman.

The planning room organization, combined with their shop representatives, remove much of the detail that is ordinarily delegated to shop foremen and gang bosses. The first mentioned few men are specially trained to several branches of the work necessary to the official operation of a plant. They are all specialists. Their duties are carefully defined and responsibility for every detail is definitely placed.

Briefly, the work of the planning room staff is as follows:

1. The production clerk is the head of the planning room. He is held responsible for those under him and their work. He sees to the proper distribution of charges of all labor routed to the shops. He supervises the ordering of material; also cost and stores records and other general details.

2. The route clerk routes all work to the shops by means of work orders and distributes this work to the proper benches, machines or men by means of the planning board, a duplicate of part of which is in each department. He does not, however, have anything to do with the "order of work" or of the records of its condition in process.

3. The order-of-work clerk is responsible for the correct processing of all work in the shops and the maintenance of shipping date schedules. He plans the order in which operations at each bench or machine are performed so as to finally bring the component parts of the work for each order through on a given date.

4. The schedule clerk keeps the process schedule, issues the daily schedule and job tally sheets to the shop, and in conjunction with the order-of-work clerk checks and follows up details of work in process. These two men also control the orders for over-

time work that may from time to time be necessary to maintain shipping promises.

5. The shop methods are controlled by the time study foreman. He is responsible for the time study work. This includes the analysis of all operations, the fixing of times, computation of bonus and the instruction of the employees until they can meet the bonus production called for. He is also responsible for the instruction cards. These cards are the final detail record of the standardized practice as finally determined after the study of conditions and completion of time studies.

Part of the times are covered on the standard time schedule of sub-elemental operation times. These times apply to all jobs. Only a few of the operations in a new job have to be timed. The bonus for a given production is obtained directly from the author's standard differential bonus sheets. These sheets show the bonus figures for any one of fifteen classes of labor for any production.

6. The material foreman, under orders from the planning room, or through the routing specified on the work orders, controls the movement of all material in process. This applies to everything. The workmen or their helpers are not allowed to go after the material they are to use. Neither are they allowed to deliver it to the next destination after they are through with their part of the work. In a foundry this applies to delivery of sand, chills, wire, nails, core plates, flasks, cores, metal (pouring gang), movement of castings, etc. In fact, all material to be moved is in charge of the material foreman. This applies from the time it is ready to move the first time until it has reached its final destination.

D. It can be readily seen that the division of responsibilities as above outlined must tend to much greater plant efficiency of operation than can be realized by holding each foreman responsible for his part of all these things. The development of an organization as above outlined must of course impress the older regime as more or less radical. This is obvious. At the same time, the method of procedure affects the smoothness of operations during the period of transition. The responsibility for this is up to the organizing engineer.

E. We come now to the selection of a competent engineer, expert in the use of methods based upon the principles of the

science of management. He should be a man of varied shop experience and have a thorough knowledge of business. He must know men and be able to appreciate the psychological influence in dealing with them. The entire problem is one of education; and success can only be obtained through a capacity which will control the ever-varying human factor while the new order is being established.

F. The successful issue lies with the engineer, but the management must support his authority to the limit. The owner cannot be too careful in the choice of an expert, but once a choice has been made, stand firmly by him. The moral effect of this attitude will remove half the obstacles ordinarily met.

G. The element of time is the essential agent which produces results. The length of time required to put any given plant on a sound basis of efficiency can be but roughly estimated. Each plant offers its own problems and each problem must be met and disposed of according to varying circumstances. Many indirect influences have a heavy bearing upon the situation.

As a general proposition, the small plant will require at least between two and three years. The larger and more complex the plant, a correspondingly longer time is necessary. What three years would do for one concern would take six to do in another. The tendency is too often to rush the work. Many failures have resulted from just this cause. Owners contemplating the installation of the new methods should bear this in mind and profit by the experience of those who have been successful in their results. Build the foundation slowly if need be, but absolutely surely.

H. We have contemplated the chief points to be considered by the owner. The organizing engineer assumes the larger responsibility when he undertakes the successful reorganization of any plant. He should make a careful investigation of the existing executive management, the official and shop personnel, the physical plant and methods. It is not safe to assume that because a plant is not run upon recognized scientific principles that it is inefficient. If this fact is overlooked, the organizer may find a condition where his services are not needed to make material improvements.

There are some lines of business which, on account of their simplicity or peculiarities, can be little improved. In any case,

conservative, sane and explicit information as to the possibilities should be given. The organizer must be sure that the principals thoroughly understand all that is involved and are in a position to see the changes carried out.

I. When a complete understanding has been reached with the owners, a preliminary report should be submitted, dealing with the unusual conditions or glaring inefficiencies. Immediate attention should be directed to such and a remedy for same found at once. By prompt recognition of such details, not only may large savings begin, but they may make the installation of the new methods pay for their own expense.

This item of cost is in many cases an important one. A realization of the fact by the engineer often enables him to carry on the work on a scale which will not prove a burden to his client. In cases where the ultimate savings are doubtful, in consideration of the cost of the change, the facts should be so clearly stated that a misunderstanding on the part of the client would be impossible. Such cases will be rare. In most cases the final, direct and indirect savings will be many times the cost of installing the modern methods. Furthermore, the gain is a permanent one and the return will be felt for years.

An efficient and permanent organization is as much if not decidedly more of an asset than so much plant. Andrew Carnegie once said that could he retain his organization, the loss of his plants would not be fatal; he could in a short time replace the latter and outstrip his competitors.

J. The next step for the engineer is to thoroughly study the available human material and plan his organization to use it. In a plant of any size there is enough material to fill all requirements. The men will have to be trained, tried out, shifted and tried again. It will be the exception who is not finally placed satisfactorily. A great asset of the old employee is that he does not need to be taught the details of the particular business. Other requisites being at all equal, he is the better choice.

The organizer must exercise extreme care, patience and tact in establishing the new line-up. He has to contend with petty jealousies, age, term of services and similar obvious conditions. One of the most difficult situations is the necessity for changing the incumbents of more important positions. This is especially

so in cases where he may have to put a man into a place of less importance, but which he is pre-eminently fitted to fill.

There is an old saying, "A new broom sweeps clean," but the writer has never found it necessary to prove the adage. There are cases where one is obliged to remove an old employee, but it is the exception rather than the rule—if the reorganization is carefully planned and built up.

Just here a word about the organization record might not be amiss. The record contains a complete set of all instructions covering in detail the duties of each member of the organization. A new incumbent in any position needs but to study them to become thoroughly familiar with his duties. Too much stress cannot be laid upon the importance of these records. They assure the maintenance of details and routine long after the organizer has completed his work. They are an asset to the firm because they show how and why each detail is handled in a certain way. No man needs miss promotion because no one else can step into his job. Neither can an employee "corner" his services because he alone knows his particular part of the work and so thinks he is indispensable. Such a man cannot be dispensed with too soon. This record is for reference of all department heads and they are invited to use it freely to familiarize themselves with the new order as the work progresses.

K. The order of procedure in working out detail in methods depends wholly on the local plant conditions. There can be no hard and fast rule. Each problem must be met in a different way. No two plants are suffering from exactly the same measure of the same elements of inefficiency. One plant, though very inefficient, may have a highly developed stores system. Another may have no stores system at all. One plant may know its costs and another not. A congestion of orders may be a great handicap and again the difficulty lies in an inability to get material when wanted. All these combinations have to be treated as they occur. Each kind of business offers its own likely chances for inefficiency. One of the greatest elements in any business is the labor proposition.

No matter how good your plant, how economical your furnaces, how much material you may have, the man is what counts. Plant, furnaces, materials! Absolutely useless without the human

agency. As stated before, labor is giving us less work per hour for a steadily increasing wage. This condition is going to grow worse for some time to come. The reasons are too well known to need discussion. We must consider the remedy.

L. "Put your house in order." Build up an adequate and self-sustaining organization. No iron-clad system and fixed detail of method can be generally applied. The true science of management lies not in a definite set of forms or a standard line of procedure.

The fundamental principles remain constant. The system, forms, etc., are but a means to an end. The entire combination, to be effective, must realize certain results. In addition to a self-sustaining organization supported by written instructions, subject to revision to suit ever-changing conditions, we must automatically reward each employee for work well and efficiently performed. He must not be left to his own devices. All the elements of his work must be under absolute control. To do this the personal factor must be recognized as paramount. This condition can be realized by fair and competent management, and the co-operation of the rank and file will be obtained permanently. Give a generous bonus in addition to the day wage, for a good day's work well done. You will have a better satisfied and higher standard of employee. Your house will be in order.

MEMORANDUM ON THE CENTRIFUGAL BLOWER FOR FOUNDRY USE.

BY DR. RICHARD MOLDENKE, WATCHUNG, N. J.

The application of a centrifugal blower, or compressor, for foundry use was first presented before our Association at the Pittsburgh Convention (May, 1911) by Mr. Richard H. Rice, of the General Electric Co., which company had brought out this line of machinery in America some time previously. While the many advantages of the type are manifest, as for instance, steadiness of the blast pressure and volume, minimum horse power required, and maintained efficiency in operation, one does not hear of its introduction into our foundries at any great rate.

It may therefore be of interest to our members to glance over the results of an efficiency test made with a blower of this type (the Rateau) built by Kuehnle, Kopp & Kausch, of Frankenthal (Palatinate), Germany. The test was made by Prof. H. Bonte, of Karlsruhe, and at the time published in complete form in the Transactions of the German Engineers Society. The figures obtained may be compared with records of fan and positive blower by those interested.

Every one in these days knows what a steam turbine is—the steam being allowed to impinge against a series of blades of suitable curvature around the periphery of a fly-wheel and this turning force to motion. In the case of the centrifugal blower or compressor, the case is practically reversed, and the turning of the fly-wheel provided with sets of blades of suitable curvature draws in the air, compresses it, and discharges it steadily and efficiently. Depending upon the number of these wheels side by side, each one giving the air an additional compression, there will be a given pressure resulting. Variations in speed mean higher or lower volumes and pressures, and taken as a whole, the machine is a beautiful piece of mechanism. Either a motor is

attached to run the apparatus, or else the shaft is continued and a steam turbine forms the other end.

Fig. 1 shows the section of such a centrifugal blower, and Fig. 2, the curvature of the blades. This system of blowing has so far been used more particularly for the blowing engines of blast furnaces (up to 15 lbs. per sq. in. pressure) and also in the compound stages for regular compressor work with 80 lbs. and above per sq. in. Hence the action is just as positive as the pressure blowers we all know of.

If it is remembered that because of its construction there is no rubbing of the blades against surfaces to keep the machine tight, but that there is clearance all over, it may be understood

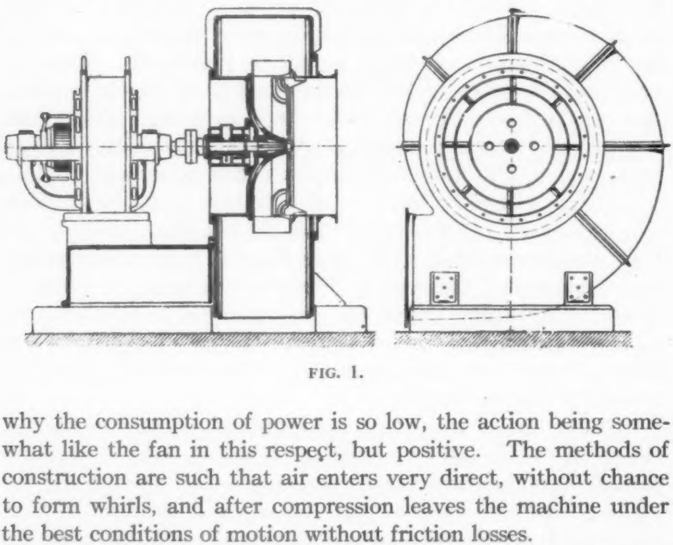


FIG. 1.

why the consumption of power is so low, the action being somewhat like the fan in this respect, but positive. The methods of construction are such that air enters very direct, without chance to form whirls, and after compression leaves the machine under the best conditions of motion without friction losses.

In the test in question there were taken two of these Rateau blowers, intended for the operation of ore roasting kilns, the diameter of the rotating impellers being 40 in., the volume delivered constantly 19,500 cu. ft. per minute, with variable pressures from 2 to 6 ins. of water. The blowers were operated by a 30 H.P. motor, which for purposes of the efficiency tests in question could be run at a variable speed of 650 and of 1000 R.P.M., direct

connected. The air pressures were measured at points where reliable results were certain, and the currents observed by using bundles of silk thread, the flow being thus readily indicated. A Robinson anemometer was used to get the air volumes.

The curves obtained from the several tests made have a peculiar shape, and there can be noticed at once that for every speed of the blower as well as for every pressure, there is a given air volume at which there is obtained a maximum efficiency. Furthermore, when running constant speed, and with variation of air volume taken and delivered (by means of blast gates) the portion of the curves denoting maximum efficiency is so extended that a comparatively wide range of air volume is allowable with-

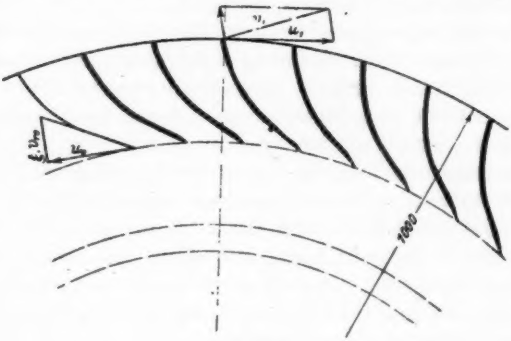


FIG. 2.

out loss in effective use of power—a thing of particular value in mine ventilation work.

From the curvature of the blades (Fig. 2) it will be noticed that air can enter from within under conditions of greatest ease and without obstruction, while on leaving the blades, there is but an angle of ten degrees made with the diameter of the rotating impeller. In the tests in question, with constant volume, the air pressures were intended to vary, in order to determine the efficiency of the apparatus. Hence it will be readily understood that to produce the higher pressures required more horse power. The actual efficiencies ran as follows: For 2 in. water gauge, it was 73 per cent; for 2.6 in., 74.5 per cent; for 3.2 in., 75.5 per cent;

for 4.2 in., 77 per cent; for 5.2 in., 75 per cent; and for 6.2 in. water it had dropped down to 71 per cent, all of which indicates a very small variation in efficiency for this type of machine for work against varying pressures for a constant volume production. This is important for the foundry, as here it is absolutely necessary that the blast, or air volume, be constant, and the pressure will vary according to the condition of the charges within the cupola. In the above case the horse power required varied almost directly from 8.5 up to 27, whereas the builders guaranteed it not to be over 10 to 27 horse power. It may be mentioned that in the efficiency calculations the temperature of the air delivered was carefully taken into account, so that the quantity of oxygen for the work required was actually delivered.

A further series of tests with another blower for blast furnace purposes brought out a number of interesting points of value for construction detail, as also along thermodynamic lines. This machine took 600 horse power to operate and hence gave figures applicable for service not found in foundries.

It is but natural that a type of blower as described is rather expensive to construct, corresponding practically to the steam turbine, and foundrymen, who use a blower ordinarily only for a few hours a day, will hesitate to spend the money for this equipment, even though the efficiency is most excellent. However, more and more foundries are going into continuous melting operation, so that the blower will operate all day long. Here it is of great importance whether the blast of the cupola is obtained in an efficient or wasteful manner.

THE PATTERN SHOP; WITH RELATION TO THE STEEL FOUNDRY.

By E. R. Swanson, Granite City, Ill.

Those among you who have given the matter any attention are familiar with the widening field for steel castings and know that the diversified use of steel castings has introduced many difficult problems in their commercial manufacture. More especially is this true of the manufacture of steel castings for railway equipment, since the use of cast steel for this purpose involves features of design that make the molding and casting of the various parts anything but a simple matter. It is the pattern shop equipment and methods required in making large intricate castings for passenger and locomotive equipment I will chiefly consider.

From being considered one of the unimportant and non-productive departments—and as a result oft neglected—the pattern shop has come to be one of the vital factors of the steel foundry organization. The location of the pattern shop with relation to the foundry, machine shop and pattern storage buildings should be well considered. It should be such that it will reduce the handling and long transfer of parts to a minimum, and the use of storage-battery trucks and mono-rail systems for this handling has been found to be economical and efficient.

The ideal shop, plan of which follows, is the epitome of modern construction. The building is of fireproof construction, one story high, with a wood floor laid on concrete. Numerous large windows on all sides, together with a lantern twenty feet wide the full length of the shop, provide ample light. An exhaust system removes all shavings and sweepings; electric glue pots, filled from a central tank, are at each bench; all machines have individual motor drive, doing away with overhead lineshafts and belts, and also reducing power costs; the lumber racks, one at each end, make it easy for the men to get their lumber with a minimum carry. The benches are placed in the side bays, which

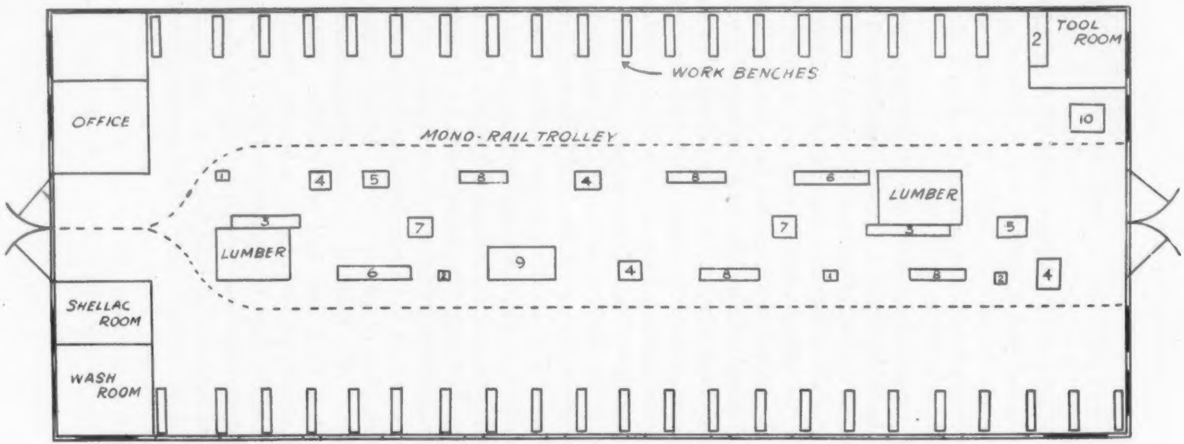


FIG. 1.—PATTERN SHOP LAY-OUT.

1.—POST DRILL.
2.—TOOL GRINDER.
3.—LATHE.
4.—BAND SAW.
5.—DISC SANDER.
6.—SWING CUT-OFF SAW.
7.—SAW BENCH.
8.—JOINTER.
9.—SURFACE PLANER.
10.—WOOD MILLING MACHINE.

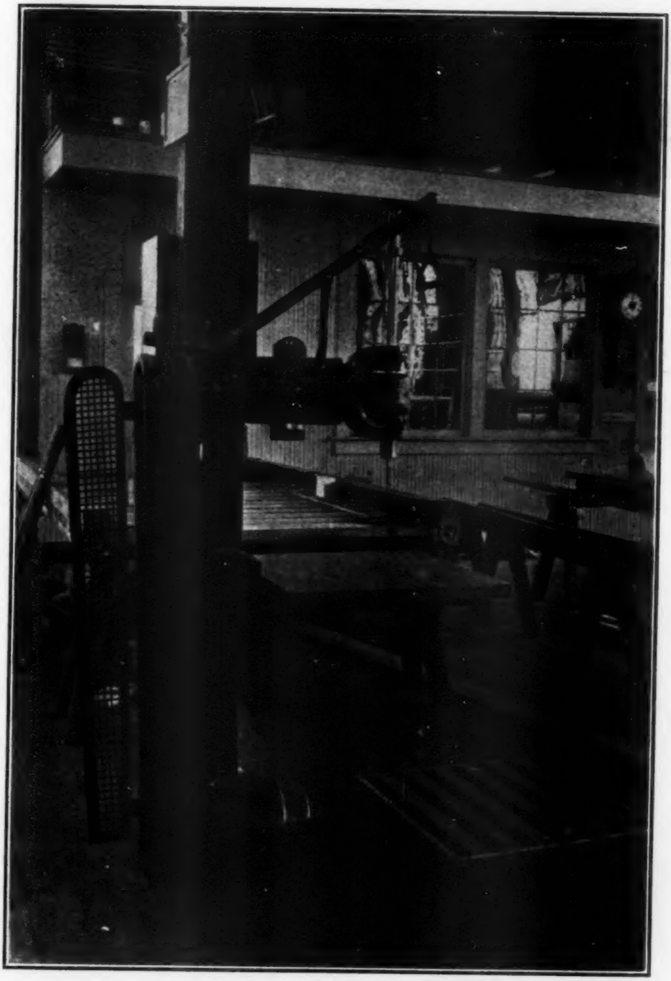


FIG. 2.—POST BORER.

are wide enough to leave room for the patterns, and all machines are placed in the middle bay where they are readily accessible to the men on either side. This system of layout facilitates supervision and proper routing of work.

The ratio of pattern maker per machine of each type for the work involved should be carefully determined and a sufficient number of machines installed so that men do not have to wait on same.

In many foundries the ratio of men injured per man employed has been very large in the pattern shop. As a result of the nation-wide safety movement, this will soon be a thing of the past. The several illustrations given herewith show some safety installations that have been found satisfactory. All machines have the bolts and gearing covered with heavy wire guards. The condition of the belts can thus be at all times observed without any danger of the workman's clothing being caught. Rubber mats on the floor where the machine operators stand prevent them from slipping and falling against machines. The jointer guard, Fig. 3, is automatically adjustable to any thickness of lumber up to six inches and can be swung back out of the way for unusual shapes very easily. It absolutely guards against a man getting his hands into the knives. The circular jointer head is also an excellent feature. Figs. 6 and 7 show safety features of swing cut-off saw. In one view the guard is swung up showing saw; in the other, the guard is assembled complete with attachment in front to prevent saw swinging against operator. Fig. 8 shows what I think is the most efficient saw guard made. This guard completely covers the saw at all times, but can be swung out of the way should occasion require.

To accurately follow the work in the pattern shop and keep in touch with its progress requires a rigid system. From his order book the foreman prepares a daily working schedule, Fig. 9, on which appear the numbers of all patterns to be worked on, the approximate time required for the job, the number of men to work per day on each pattern and the date that has been set for the making of each sample. Each pattern maker fills in a daily time card, Fig. 10, which shows the time worked on each pattern together with the material used on each. The daily cost of each pattern is posted under its proper number on a form, Fig. 11,

FIG. 3.—JOINTER GUARD.

FIG. 4.—BELT GUARD ON PLANER.

FIG. 5.—BAND SAW.

so that when finished the total cost can be had quickly and by comparison with records on similar work an excessive cost be quickly determined and the inefficient workman weeded out.

A sample casting should at all times be made. A pattern maker, detailed for that purpose, directs the setting of cores in the sample mold and he reports any discrepancies that may have occurred in pattern or core boxes. The sample casting in turn is checked with the drawing and from the two reports the pattern foreman is enabled to intelligently direct any changes necessary on pattern before it is run regularly in foundry.

The matter of pattern and core-box storage has long been a perplexing question. A costly fireproof building, generally of concrete with metal racks, fire doors, etc., is an expensive luxury. Many shops have found it to be an economical as well as a safe construction to make their buildings of wood and corrugated iron with composition roofing, the buildings in all cases to be detached and reasonably isolated and protected with an automatic sprinkler system. The use of a card index system in storing of patterns is invaluable. The storage buildings are numbered consecutively. In turn the floors, racks, shelves and sections are numbered. A card, Fig. 12, is filled out when the pattern is finished. Should it be sent to the foundry the proper notation is made, but if stored some such notation as 1-2-3-4-5 would be made in the storage column, indicating that the pattern was in building No. 1, floor No. 2, rack No. 3, shelf No. 4, and section No. 5.

As a rule, you will find the men in charge of the pattern shop and the mold shop have risen from the ranks of their respective trades and in too many instances does the old friction between the pattern maker and the molder creep in. There is in the average steel foundry a vast amount of details requiring attention, and this friction tends to produce a proneness to shift responsibility for the various troubles that arise. Because of this, I think it an excellent plan to have one man in direct charge of and responsible for the operation of the two departments. This system of control will result in conferences between the pattern and molder foremen as to the best method of making incoming work; and in passing let me advance the suggestion that it would be an excellent requirement that every pattern maker should spend at least six months apprenticeship in the core room and

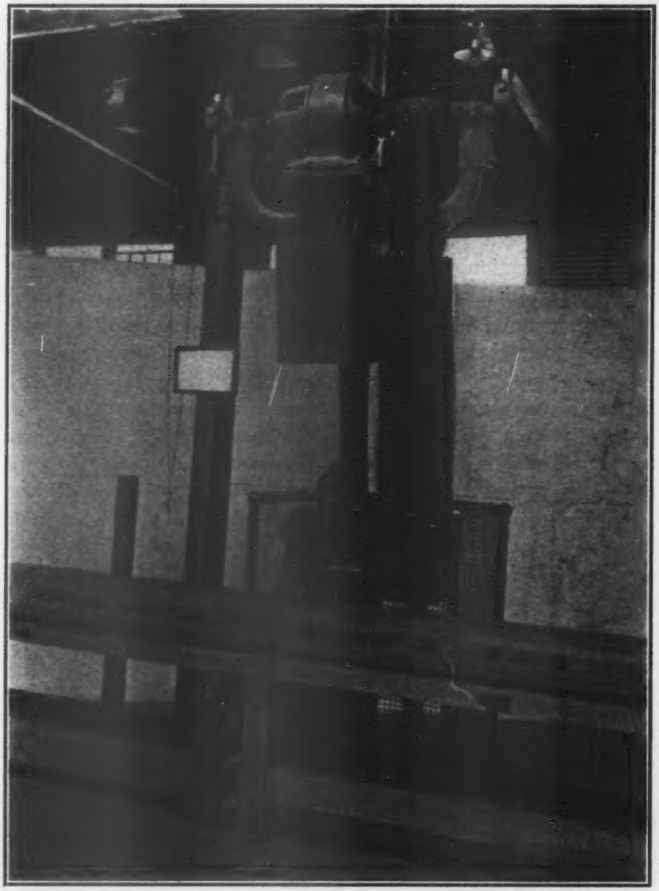


FIG. 6.—SWING CUT-OFF SAW.

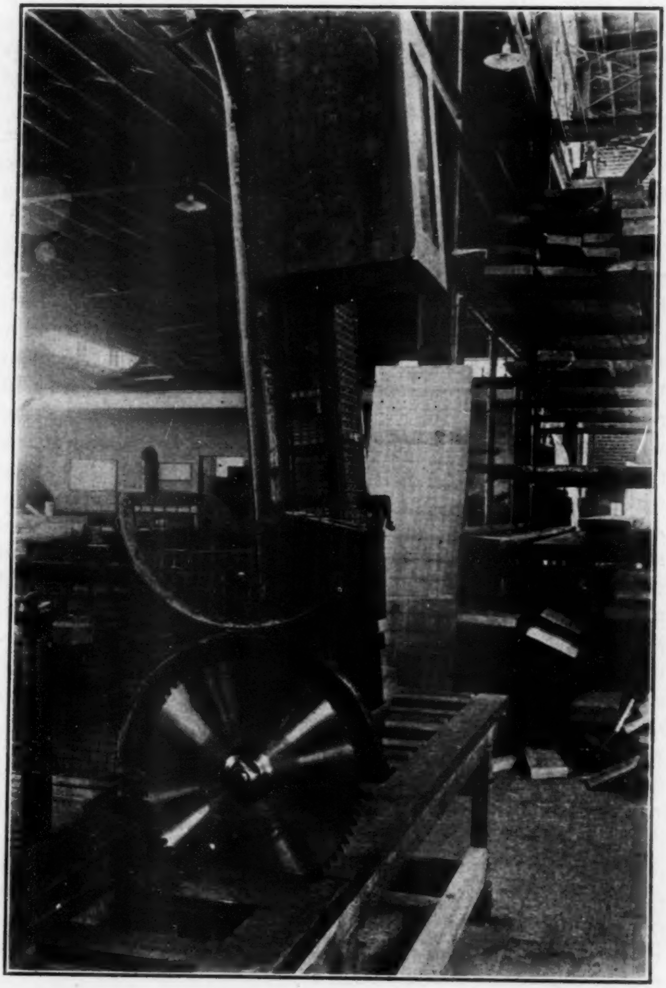


FIG. 7.—SWING CUT-OFF SAW.

mold shop. By means of this apprenticeship they would see the use that is made of the product of their skill and this would give them a first-hand knowledge of foundry requirements that so many journeymen pattern makers do not acquire without years of experience.

The use of stripping plate and jarring machines has become well-nigh universal, and the method of making large, intricate castings in quantities, commercially, by means of assembling dry sand cores without the use of a cope is being developed. The advantages of this method are that a mold can be made in a much shorter time and the output per square foot of foundry floor space practically doubled, as no copes are required. Incidentally, the problem of rigging and lifting large, heavy copes is solved. On the other hand, there are many problems incident to this method of production that are difficult of solution. In many cases from seventy-five to one hundred core boxes are required for the large patterns; hence it can readily be seen that a maximum of skill in the pattern shop is required in both the supervision and execution, else the job will not fit together properly. Also many of the shrinkage, molding and core-making difficulties must be anticipated in the pattern shop. The use of dry sand cores in this manner produces the equivalent of a dry sand mold and this tends to produce a smooth casting free from blow-holes; but it also requires skilful manipulation to take care of the abnormal shrinkages, or rather lack of shrinkage, that take place in cooling. The allowances to be made can only be determined by observation, based on experience, and in many cases parts of the pattern are made without any shrinkage allowance whatever. This of course requires skilful scrutiny of the proposed designs to guard against those features that will tend to produce cracked castings.

The core room will necessarily have to be provided with ample equipment in the way of large straight plates to insure straight cores and oven capacity to dry the heavy cores slowly and uniformly. Frequently the area of the core room will be fifty per cent of that of the molding floor.

To accurately follow up the numerous core boxes required by this method of molding necessitates a rigid system of some sort being followed, since shops using this method will occasionally

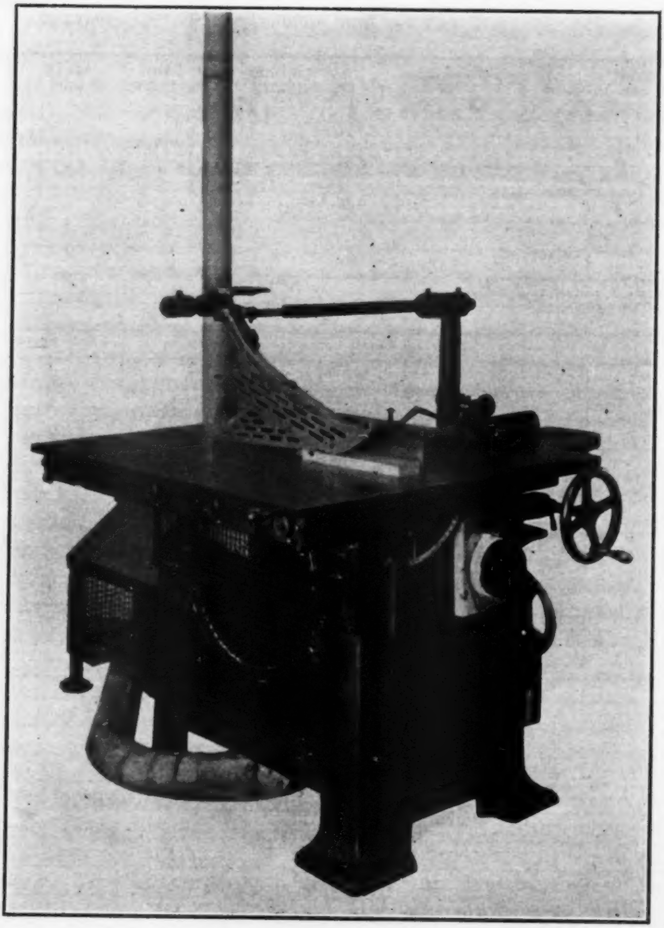


FIG. 8.—SHOWING APPLICATION OF SAW GUARD.

PATTERN SHOP SCHEDULE DATE

PATT. NO.	DESCRIPTION	DAY'S WORK ON PATTERN	MEN WORK CN PATTERN	MAKE SAMPLE

FIG. 9.

have from two to three thousand boxes in the core room at one time.

To solve this feature an ingenious system has been worked out in one shop that may be of interest to you. A form, Fig. 13, that has been properly filled in at the pattern shop accompanies each job to the core room. The core boxes of each pattern are numbered consecutively from one up. This serial number together with the pattern number appears in each box, thus:

5860 5860
1, 2, etc.

NAME					
CHECK NO.		DATE			
PATT. NO.	DESCRIPTION	HOURS	LUMBER	FILLET	MISC.

FIG. 10.

and by referring to the form and his working schedule, the core room foreman can have the proper number of cores made from each box. These numbers are preserved on the cores and by means of this form a complete set of cores can be assembled by unskilled labor. The diagram sheets referred to are outlined drawings of the various castings on which the location of the various core boxes are marked and these facilitate the checking of pattern and core boxes and insure a complete set of core boxes for each job being sent into the core room.

PATT. NO.	DESCRIPTION	
DATE	LABOR	MATERIAL
TOTAL		

FIG. 11.

PATT.	NO. CORE BOXES	NO. PAT-TERN	DESCRIPTION	KIND	DATE	TO F'DRY	STORAGE

FIG. 12.

PATT. NO.	DESCRIPTION	KIND	DIAGRAM NO.	DATE

BOX NO.	NO. CORES	BOX NO.	NO. CORES	BOX NO.	NO. CORES

FIG. 13.

MALLEABLE TROUBLES.

By Dr. Richard Moldenke, Watchung, N. J.

That the troubles incident to the production of malleable castings are far more trying than those experienced in other branches of the iron foundry is due to the fact that about half the material melted consists of shop scrap. Any deficiencies in the stock purchased or in the metal produced through poor practice ingrafts itself upon the scrap, and unless promptly diagnosed and corrected becomes more aggravating from day to day, ending in serious commercial disaster. The unfortunate phase in the situation is that once the trouble has been located and corrected, the malleable man has the disagreeable prospect of taking a week's work from the ovens, all of which he knows to be of inferior quality.

In spite of the fact that the malleable process has not been changed or much improved since the earliest times—simply because radical changes in the heat treatment applied takes the material entirely out of this class of castings—the subject requires a life study, and even with such an experience much that occurs must be left to scientific speculation. With the constantly increasing researches being made into this fascinating subject, there is reason to believe that we may soon know more—provided that the students base their conclusions upon actual practice combined with laboratory research, and not the latter alone.

Let us first enumerate the more prominent "malleable troubles," try to locate their cause and finally suggest the cure in each case.

The two principal characteristics of bad malleable castings are the so-called "low" and "high" irons. In the range of malleable work, depending primarily upon the silicon content, thickness of section, and to a smaller degree the temperature of the metal poured, there will be found on one end of the series the extremely weak, gray fractured metal, absolutely ruined through

oxidation in annealing the hard castings. This is sometimes so open in structure, through oxidation of the graphite which should not have been there, that on breaking a piece of this extremely "low" iron, the fracture is highly colored with bands of blue, red and yellow alternating through it and showing up the arrangement of the crystallization scheme very nicely. This "calico" iron is perhaps the very worst trouble the malleable casting producer can have, for it is more dangerous than the commonest cast iron.

From it—as the deposition of graphite in the original hard iron becomes less and less—we get the malleables that approach ordinary gray iron in strength, and might as well have been made in the cupola and not annealed. Still a little better, and we have malleables which are eminently suitable for work which must be machined like cheese, and yet be soft enough not to fracture under shock too readily. As for instance, air brake light parts, and in the better grades, pipe fittings. Metal of this kind is, however, made quite specially—in separate heats—as getting this material into important work is too serious a question.

The range of malleables now comes into the good work, and here there is a fair chance to get heavy and light work from the same heat, if the proper portion of the bath as it empties out of the furnace is caught. This naturally relates to "furnace" iron and not cupola work. We have here the two characteristics of white iron to make use of. Granted that there is a slight lowering of the silicon during the tapping process, as it usually takes one-half to one hour to get out the ordinary heat, and the heat itself having been ready to pour into castings when tapped, the first part, with higher silicon, would be more suitable for lighter castings than the last, if hot enough to pour at all, whereas the last iron, even if ordinarily too high in silicon to be safe if poured cold, will come out all right on account of the extremely high temperature existing in the metal at the end of a heat.

Very light castings, of course, must be poured from the hottest iron made, and hence those works in which the heavy range of car castings are produced have their difficulties in making iron suitable for strong heavy castings, and yet turning out quantities of very light castings with the same metal, and with consequent heavy losses from misruns, blows and the like.

I have always felt that the solution in cases like this is to make the mixture low enough in silicon to suit the heavy work. Tap out that portion of the heat, close up the breast, add ferrosilicon enough to the bath to bring the metal to a silicon content proper for very light work, allow to heat up properly, and tap again to pour all the light castings. I may say right here that this method of procedure is recommended with much reluctance, as there is nothing worse than having to add silicon to a heat of malleable where strong heavy sectioned "specification" metal is wanted. This is never necessary unless the heat has been run wrong in the first place, or the bad policy of using a furnace larger than twenty tons capacity has been adopted. Metal in melting is under oxidizing influences all the time it is in the furnace, and hence it should be the aim of the melter to get his metal under a slag cover as rapidly as possible. Next to heat it up as rapidly as the furnace will permit, and finally to tap out as fast as men can take it away.

Now given a heat melting in say two hours longer than the normal, there is a gradually increasing percentage of iron oxide dissolving in the bath, while the silicon content is lowering abnormally. Adding ferrosilicon while intended to restore the silicon content, and actually doing this, also deoxidizes the bath. This looks good on the face of it, but unfortunately the products of this deoxidation have a way of not rising to the top very quickly but remaining scattered throughout the bath of metal and going into the castings. So here we have a theory which does not work out, and the reason is that malleable temperatures are too low. In the case of a steel casting heat we have a temperature hundreds of degrees above that of malleable—which in even the hottest condition is lower than ordinary heat for gray iron work—and consequently the deoxidation is rapid, and the slag formed rises out of the metal in time for efficient use. That this is not the case in making malleable I know not only from actual pyrometric readings of the metal taken in the furnace and just before pouring the molds, but from years of records of tensile and transverse tests made on the first and last portions of thousands of heats. I claim that the addition of ferrosilicon to heats lowers the value of the metal for making castings. You can prove this for yourself by taking a series of observations, not isolated cases, on test bars cast from the first and last of heats—not the middle.

Further, by taking not half inch square, or three eighths inch round bars, but good big inch square test bars. These will tell the story without having you deceive yourselves.

The practical application of the above lies in your melting arrangements. A malleable melter knows how to distribute his charge in such a way that it melts in the shortest time possible. A steel melter dumps the charge in incongruous heaps. Result a heat longer by at least half an hour for the same tonnage. The malleable melter works his metal to promote uniformity in temperature and acceleration in getting ready for the test and then the tap. The steel melter sits down and lets the heat simmer. When his test eventually shows that the silicon has gotten too low, that is, the plug shows white iron throughout, with fine pin holes along the rim, he adds ferrosilicon and sits down again. When hot he taps. The comparison between the two methods is best shown from the fact that, say, a ten-ton heat from the air furnace takes a malleable melter not over four hours to get ready from end of charging to time of tapping. The same heat will often take the steel melter seven hours.

To recall my own practical experience, I will mention that for years, with self-trained malleable melters the tensile strength of daily heats ran up to 51,000 lbs. per sq. in., and the same 1 in. square test bars would bend up to $2\frac{1}{2}$ in. before failing. Then a steel melter was given charge of the furnaces, the heats soon increased in length, ferrosilicon was added as a common occurrence, and the average strength of the test bars dropped down to about 43,000 lbs. per sq. in. Moral—keep steel melting methods out of the malleable shop, watch the firing so that a uniform stream of intensely hot flame heats up the brickwork of the roof and side walls of the furnace, and no cold air puffs from open furnace doors check this temperature any more than may be necessary.

To return again to the original argument—after this ferrosilicon digression. From the good work, after leaving the "low" iron range, we get into the so-called "high" irons. As the silicon content in the metal becomes lower, the heats longer than necessary, and the metal hotter, this begins to show signs of gas formation within the structure, noticeable more particularly on the surface of the castings. The fracture, instead of showing the

characteristic fine band of white for the skin, next the eighth inch or so band of gray to black where the crystals of iron have arranged themselves at right angles to the surface planes, and then the black interior, begins to show a broader band of white, indicating that by reason of a more open structure the oxidation effects of the packing and air currents in the saggers have penetrated more deeply into the castings. The castings are weaker, the surfaces not as smooth, the edges become rounded, in bad cases the metal has wasted heavily by scaling off, and as this trouble progresses, the material finally becomes brittle and unsalable. At all times, however, so long as there is an annealing action, the metal is not as bad as "low" iron. Hence it is better to err on this side of the series than on the high silicon side.

Now, unfortunately, it is quite possible to have "burnt" iron, with the proper silicon content, and that brings us to the melting problem. Before going into this, however, there may be stated that when the silicon gets so low that the hard castings are full of blow-holes, molds become short-poured even with very hot metal, and there is no sign of annealing effects on taking from the ovens, the other end of the series will have been reached.

As there is no establishment that sooner or later does not make all of the above described varieties of malleable, I would suggest that a cabinet of fractured pieces be established in the superintendent's office—preferably the broken test bars of 1 in. square section where heavy work is to rule, and inch by half inch where very light work is made only—and that gradually the series from very "low" to very "high" malleable be accumulated. Some thirty pieces, each one showing a shade different from the next, can thus be had, and this series forms the best kind of a sermon for the edification of the foremen and melters when things go wrong. Moreover, a watchful president strolling through the shop can pick up a few castings, have them broken, and compare fractures with this standard series of "bad to good" and "good to bad" in a line.

The melting problem has been mentioned above, and without wishing to weary you, as books could be written on this phase of iron metallurgy alone, I will say that variations in temperature and time in the anneal may ruin a good hard casting, but not even the best annealing practice will make a poor hard casting

into a good piece of malleable. Hence before condemning the annealer it is always well to look into the melting practice first—presuming that normal irons and scrap have been used.

In melting iron for malleable in the cupola nothing more can be said than that the precautions to be taken for gray iron apply here more particularly even, as we deal with very low silicons. Here the charges must be very small to avoid fluctuations in the position in the melting zone, and, moreover, it is necessary to melt quite high in the melting zone, in order to keep away from every possible chance of oxidation. Hence a very low fuel efficiency is essential.

In the case of the air furnace as well as the open hearth furnace, the first thing to watch is the charging. As stated above, the careful melter so disposes his charge that the sprues melt first and form a pool of iron into which he can throw one pig after the other from two piles carefully laid in regular order as if in the stock yard. If possible these piles should be spread over the furnace bottom somewhat so that they heat up in quickest time. But they should be laid perpendicular to the side walls, so that an iron bar inserted into the furnace will push one pig at a time into the bath as desired. There seems to me nothing more unsatisfactory and inefficient than to see a melter try to loosen up a pile for this purpose and perhaps break off a little at one end of a softening pig, the other sticking fast within the pile. Naturally he gives up when physically exhausted, and nothing of value is accomplished. The pile simply has to melt down of its own accord and not assisted by the melter. The result, however, is that the heat is longer, coal is burned unnecessarily, and worst of all, the iron is injuriously affected.

Next comes the firing itself. In the case of the open-hearth furnace, with gas or oil firing, the problem is simple enough for this end of the operation. The care of the furnace is another matter. In the air furnace, however, the greatest possible attention should be given to the problem. As in boiler practice the best results are obtained by clockwork-like precision of opening the door, inserting coal close to it, closing to allow the coal to begin coking and at the same time giving off gas to pass over the hot bed of fuel, then opening the door and pushing the coals over the fire bed, etc.; so also in air furnace practice this routine

should be followed out. There is this extra precaution, however, in the latter case. In boiler practice about **100** per cent air in addition to that theoretically required is allowed to enter, and thus the maximum value of the coal is obtained. In air furnace practice, however, where we need extreme temperatures rather than high fuel efficiency, not more than 25 per cent extra air should be allowed into the fire-box end of the furnace, otherwise the heat will be prolonged unduly. It is not the flame that does the best melting, but the radiation from the incandescent brickwork of the combustion chamber of the furnace, which means that a surface as unbroken by defective doors, etc., as possible, heated up to the highest degree safe for the bricks, and kept that way steadily by a stream of uniform fire should be presented to the metal charge. In how many establishments is this the rule? I have seen but few myself. There is more room for improvement here than anywhere else. A very efficient furnace charging door on the market, in which it is impossible to open the door at all while firing, has solved this problem nicely. Indeed, it was gotten up at my suggestion, and worked out into its present shape during trials made to show the melters affected that it was possible to get out excellent heats without open fire doors—a thing claimed impossible by them—where the furnaces are so proportioned that a twenty-ton heat was not expected to be taken from a ten-ton furnace. In spite of this excellent arrangement, I cannot help but feel that for the class of coal always used for melting with the air furnace, the chain grate is the coming solution of the firing problem where the necessities of the establishment require the air furnace at all. Where a works has steady occupation for a furnace the year around, the open-hearth installation is the thing to put in—but to put in right.

With this discussion on the melting problem understood, there is to be said that with proper mixtures and proper melting, so that when a heat is ready to tap it is also hot enough to do this, only high grade metal will result. Long heats, through poor firing, or inexcusable composition errors in these days of chemical laboratories, mean iron that goes to the anneal with every chance of poor results. To this should be added that even with the best of hot iron running from the spout, if a shank

of, say, 150 lbs. has to be carried to the other end of the shop before pouring a heavy section casting, trouble is almost certain to result from "low" iron. Hence judgment should be used in placing the patterns, so that only hot iron may go where it is most needed.

While "low" iron usually pours like gray casting work—that is, with a minimum molding loss—even though the castings themselves are worthless, "high" iron, on the other hand, gives rise to a variety of casting troubles, such as shrinks, cracks, pin holes, blow and gas holes, etc. The molding loss sheets show astonishing black spots for castings that are sensitive to variations in the iron. There is only one grade of iron right for the malleable shop, and this grade can readily be made if the executive knows how to compel its production.

Turning next to annealing troubles. While scientific investigation in laboratories shows all kinds of errors committed by the practical malleable man in keeping time and temperatures of the ovens as he has them, yet we all know the fate of establishments where quick anneal and high temperature practice has prevailed. The sheriff gets them. Unless, indeed, the Reaumur or Continental European process is used—where temperatures and times of anneal are used which practically decarbonize the metal (and thin metal only at that) so that the fracture is a steely white—the good old process taking 60 hours of full temperature of around 1350° F. for the coldest pot in the coldest part of the oven should be used. Then one knows that when the iron from the molding floor comes to the anneal, it will issue nicely and as a good material. If oxidized in the melting, no skill of the annealer can correct this.

The two troubles incident to annealing practice are "over-anneal" and "under-anneal." The former, by running the temperatures too high, so that the metal opens up and the fracture shows heavy white bands, if not entirely white (but steely and not crystalline as in the hard casting); and the latter, by showing but an imperfect change from the crystalline structure of the hard casting to the fine soft gray of the good malleable casting. It is sometimes quite difficult to distinguish the two, particularly when a casting is almost fully annealed. On closely observing the character of the white rim, however, the distinction

can be made, for when over-annealed the white band does not show sharp interior corners, but rounded ones, which as the band goes inward further eventually leaves the black-heart a round spot. A comparison of a number of fractures from the same oven will show a range of pieces which tells the story, as in the case of over-anneal there will be few good pieces, and none with the original hard structure, while with under-anneal there will be good castings and a few hard ones. In the latter case the whole charge, or at least the coldest pots, can be returned for another anneal. In the former there is no help.

It would carry us too far to go into the simple mechanical troubles like warping of castings or sticking of sand or scale. The solution of such troubles is self-evident.

OXY-ACETYLENE WELDING AND CUTTING AS APPLIED TO THE FOUNDRY.

By H. P. Harding, Chicago, Ill.

In the last few years the oxy-acetylene welding and cutting process has become generally familiar to everyone connected with the metal-working industries. The applications of the process of welding and cutting metals extend to every branch of the industry.

Although the process has been found invaluable in almost every department of the up-to-date plant, I will, however, confine my attention here to its application to foundry practice, and, in the space available, endeavor to illustrate by photographs of everyday work, this efficient way of eliminating the foundry scrap casting account and reducing the cost of output.

This process, even more wonderful and flexible than the electric furnace, is revolutionizing the metal-working industry. With it may be welded into one, two parts of iron, steel, brass, copper, bronze, aluminum, platinum and other metals by fusion without subsequent compression. It is the most economical method known for cutting wrought iron and steel. For light or heavy repair work and special jobs, it is in a class by itself.

The practicability of the process has been thoroughly established by successful use under ordinary everyday working conditions in thousands of metal-working plants throughout the country. In the few years since its introduction it has become most important commercially, its value being estimated at many millions of dollars annually.

When everyone interested in the advancement of the metal-working industry gives more careful consideration and understands more thoroughly the effectiveness and availability of the process, its use will become universal where metal is to be repaired, joined or cut. Its application even today extends to an almost unlimited number and variety of operations.

The commercial possibilities of the process are being rapidly extended, since many of the largest engineering concerns throughout the world have adopted it. New applications are being discovered daily. Many operations which a few years ago were considered impossible or difficult of accomplishment are being carried on today as a matter of ordinary shop practice.

In considering either the theoretical or practical applications of the process, we must bear in mind the inherent characteristics of the metals upon which we are working. For instance, every man in a foundry is familiar with the fact that iron and steel contract and expand when subjected to temperature changes. Due allowance must therefore be made for expansion and contraction in every stage of the manufacture of iron and steel. On the other hand, some metals, such as aluminum, brass, copper, etc., oxidize very rapidly under high temperature conditions.

Failures which in the past have been attributed to the oxy-acetylene process are almost without exception traceable to two causes: first, poor equipment, including generators, torches and other accessories; and second, lack of intelligent handling on the part of the operator.

It must not be inferred from this that the process is either extremely difficult or that it requires more than ordinarily intelligent operators to secure successful results. Quite the contrary is the case.

Some purchasers of welding apparatus believe that it is a mysterious force which will be the "cure-all" for all of their difficulties. While almost incredible results, with enormous savings of money, time and material, are being effected daily in thousands of metal-working plants throughout the country, it should always be borne in mind that the metals being handled will act no differently or exhibit no new phenomena under the oxy-acetylene flame than they do in the cupola or ladle.

The Scrap Casting Account.

This account is always a serious item to the foundry superintendent and if reduced by even fifty per cent, many hundreds of dollars annually will be saved in the average plant. The intelligent use of the welding blowpipe in many foundries is, however, eliminating not fifty or sixty per cent, but the entire loss.

You will note in Fig. 1 a defective cast-iron turbine casing. At the point indicated by the arrow there is a small shrink hole which, under ordinary conditions, would have made it of only

FIG. 1.

scrap value. The casting weighed five hundred pounds and was in perfect condition with the exception of this one defect.

The actual cost of welding with the oxy-acetylene process

was somewhat less than $2. The casting was three feet in diameter, four feet high, and was welded in one hour's time after preheating in a charcoal fire for about three hours. Fig. 2 shows the completed weld.

FIG. 2.

Aside from the welding of blowholes, surface cracks, cold shuts and other defects which occur in the casting room, the process has proved equally efficient for adding on metal to accommodate changes in design or to rectify mistakes in pattern making.

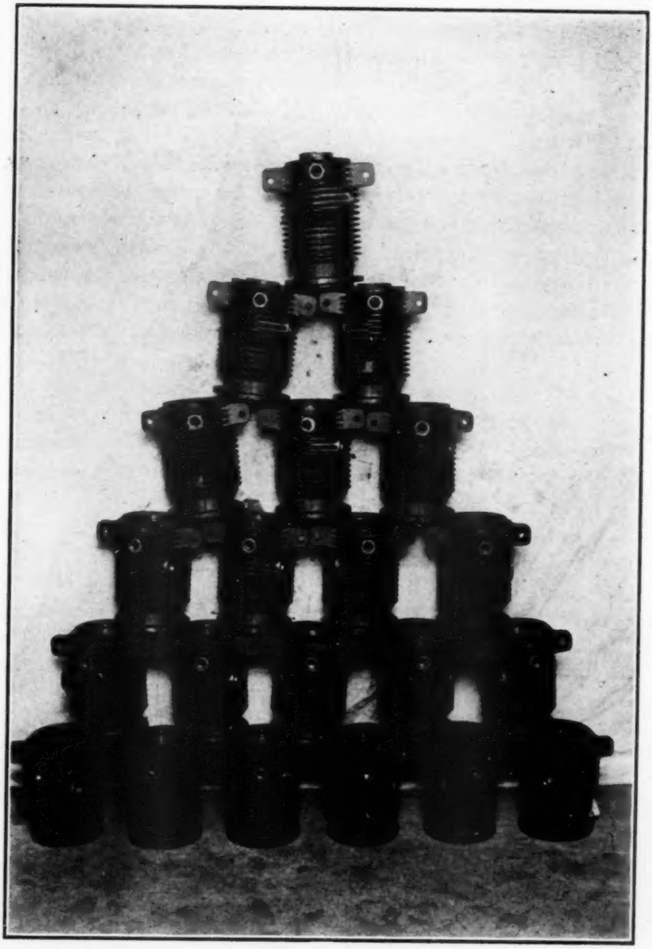


FIG. 3.

An illustration of this class of work is now shown in Fig. 3. Twenty-one castings which were part of a lot of special air-cooled cylinders recently cast in a large foundry. Each cylinder was $4\frac{1}{2}$ in. in diameter and was equipped with a special lug. The cylinders were cast, machined and threaded ready for use, but when assembled it was found that the lug on which the oil intake pipe should have fitted was not sufficiently long for the purpose, owing to a change in design after the castings were made. Each casting was valued at from ten to twelve dollars, and for certain reasons it was impractical to lengthen the oil pipes to fit. As there were about fifty castings in the entire lot, the loss involved was considerable, to say nothing of the time wasted. Instead of casting a new batch of cylinders, the defective ones were reclaimed with the blowpipe. Each cylinder was preheated locally and new metal added to the oil connection until it was of the proper length, after which the thread was cut and the cylinders fitted as though there had been no error in the first instance. The average cost of the work was from twenty to twenty-eight cents per casting. This compared with the original value of twelve dollars makes an average saving of $11.76 per casting, or nearly $247.

A few jobs of this kind would more than offset the initial cost of welding equipment.

Fig. 4 illustrates the welding of cast iron stove patterns, a comparatively new field for the application of the blowpipe. In the average stove casting foundry it has been difficult to introduce the process, owing to the very small cost of the castings produced, and considering the fact that almost all of these castings are made upon a piece basis, therefore if defective, the cost of labor is not considered. It has been found, however, that the welding of stove casting patterns can be accomplished successfully with the blowpipe, representing a very marked saving in the maintenance cost of patterns. This photograph shows a cast iron door frame pattern. Before the application of the process to repairing stove patterns, they were patched in rather a clumsy manner and at a cost considerably greater than the cost of adding metal with the blowpipe.

Fig. 5 shows a section of a cast iron heating boiler after the crack had been welded. The weight of the casting was 500 lbs.

This application of the blowpipe to the reclaiming of boiler sections is a comparatively new field for the process. The castings are difficult to make and a good deal of trouble is experienced from shrinkage cracks, blowholes, etc. In some cases, the casting is taken from the mold in such shape that it would not pay to weld it, but in most foundries carrying on this class of work, the majority of the defective castings can be economically and satisfactorily welded with the blowpipe.

FIG. 4.

Cutting Risers, Sprues and Runners in the Steel Foundry.

It is of course well known among men familiar with foundry practice that a cutting blowpipe is of immense value for cutting risers, sprues and runners from steel castings. There are no doubt some instances in which it is more convenient to nick the riser and knock it off with a sledge, but there are thousands of cases in which this cannot be done and the risers must either be cut with a saw or with a blowpipe. If they are cut with a saw, they must be picked up bodily by a crane and taken to that part

of the foundry where the saws are located, and must then be adjusted to the saw for each separate riser.

If a cutting blowpipe is used, it is taken to the casting and the risers cut, without having the change its position in any way.

FIG. 5.

In many instances, a pipe line to carry acetylene is run throughout the shop to convenient points, and in others, the plant used is of the portable type which can be readily moved from point to point in the foundry.

Large risers may be cut with the blowpipe in a fraction of

the time which is required with the saw and in most instances at less cost.

It often happens that when the output of a foundry is unusually large, the saw equipment is not sufficient to handle it expeditiously. The saws become congested and cause considerable delay in the delivery of the castings. In such cases, the cutting blowpipe is absolutely necessary to relieve the congestion. In any event, the modern foundry is not considered completely equipped until it has an oxy-acetylene cutting blowpipe in use.

Fig. 6 illustrates a large steel casting for a water-power

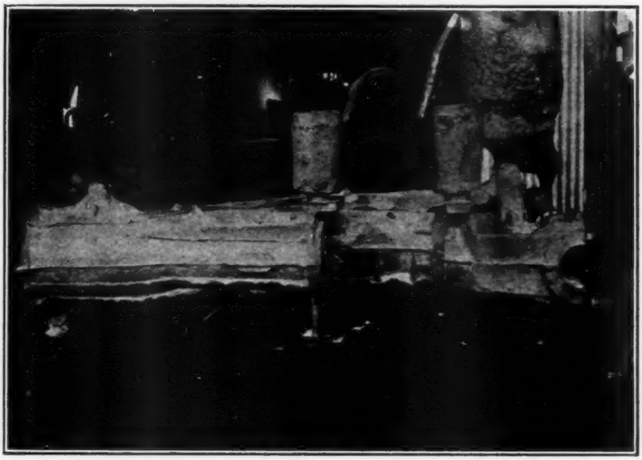


FIG. 6.

plant. From this casting six risers, ranging from 2½ by 7 in. to 5 by 16 in., were removed with the cutting blowpipe in forty-two minutes. It would require 5½ hours to cut them with the saw. The cost of cutting them with a blowpipe was $4.15.

The average cost of cutting risers with the blowpipe is about 1.4 cents per sq. in. In some instances, where cutting is difficult or inconvenient for the operator, this cost may be more than the figure given, but under ordinary conditions the average cost will not be higher. The particular advantage of the blowpipe is that castings are kept moving from the molding room to the finishing

room at a much higher rate of speed than is ever the case with a battery of saws. One cutting blowpipe has the efficiency of from five to ten saws.

Fig. 7 illustrates a large pump casting, the weight of which was 2,200 lb. There were six risers on this casting ranging from $2\frac{1}{2}$ in. thick by 7 in. wide to $4\frac{1}{2}$ in. thick by 15 in. wide, which were cut off by one operator with a blowpipe in twenty minutes at a cost of about $3. To saw these risers would have required at least six hours' time.

FIG. 7.

A large pile of steel castings is illustrated in Fig. 8, showing how easy it is to cut risers no matter what the position of the casting. This, of course, saves a good deal of time with the crane. As is perfectly well known when using saws exclusively, the casting must be turned and adjusted for each riser. After from five to ten risers have been cut the saw must be re-sharpened. All of this work is eliminated with the blowpipe.

One large manufacturer has reported that the blowpipe saves him about twelve cents per ton on his entire output. Such a figure of course depends largely upon the individual conditions in

the foundry, and in many instances may be very much greater than this.

The operation of the cutting blowpipe is so simple that it can be mastered by the average workman with ordinary intelligence in a few hours. Specially skilled workmen are not required to secure results that would be difficult or even impossible with other means. Speed in cutting naturally comes with practice. The instances illustrated herewith can be duplicated in any steel foundry after the workmen has had a little experience. The following instances which I mention compare the

FIG. 8.

work done with a cutting blowpipe to the ordinary method of sawing:

One riser 8 in. in diameter cut with the blowpipe in six minutes. Two and one-half hours would have been required for sawing.

Two risers, 12 by 2½ in. four minutes. Time required to saw would have been three hours.

Four risers, each approximately 4 by 14 in., cut in twenty minutes with a blowpipe. At least five hours would have been necessary if a saw had been used. Six risers, 2½ by 9 in. removed

in thirty minutes which would have required six hours by other means.

Broken Castings.

While the following illustrations represent work which does not apply directly to the foundry, they are of interest to every foundryman because they show to advantage the many and varied breaks in iron and steel castings which can be satisfactorily welded. Of course, some of these breaks are caused by internal stresses in the casting, which result from shrinkage in the foundry. These strains may be adjusted by re-heating or annealing after welding. Fig. 9 shows a punch-press casting broken in three parts. It weighed 500 lb. and its value was about $75. It was welded in $8\frac{1}{2}$ hours' time at a cost of $17.82. The height of the casting was $4\frac{1}{2}$ ft., and the width at the base $2\frac{1}{2}$ ft. Fig. 10 shows the casting after being completed. It is now as good as new and can go back into service with a saving of $57 in money and a very considerable delay, which would have been necessary if a new casting had been purchased.

The saving gained by the use of the process in an ordinary car-repair shop is tremendous, and a great deal more than is ordinarily realized. In one instance, this saving amounted to approximately $1,200 a month, or more than the initial cost of the plant each month.

There seems to be practically no limit to the thickness of the metal or the size of the casting which can be welded, provided it can be preheated or so controlled that the operator can properly handle his blowpipe.

A very extensive field for the process is the repairing of broken automobile cylinders. Fig. 11 shows a cylinder casting, which, under ordinary circumstances, would be out of the question to repair. The view shows the outer wall of the water jacket cut away to permit welding of the cylinder. After this was repaired, the piece in the outer wall of the water jacket was welded back into place. The value of this cylinder casting was about $60; the cost of welding about $3.73. In such cases as this, the saving in money is not always the feature which is most to be considered. If the casting is of an obsolete pattern, or if it necessitates sending a distance for a new one, the time lost while the car is laid up is

FIG. 9.

FIG. 10.

an even more serious item. This is especially true of trucks and other business vehicles, whose revenue is frequently figured at from $15 to $50 per day. Fig. 12 shows the completed job.

Fig. 13 represents a large cast iron gear wheel, weighing about five tons. Ten teeth were broken away. The diameter of the wheel was approximately 8 ft. The repair was made in less than a day and a half at an expense of about one-tenth of the cost of a new gear.

It is interesting to note the method of bricking up that part

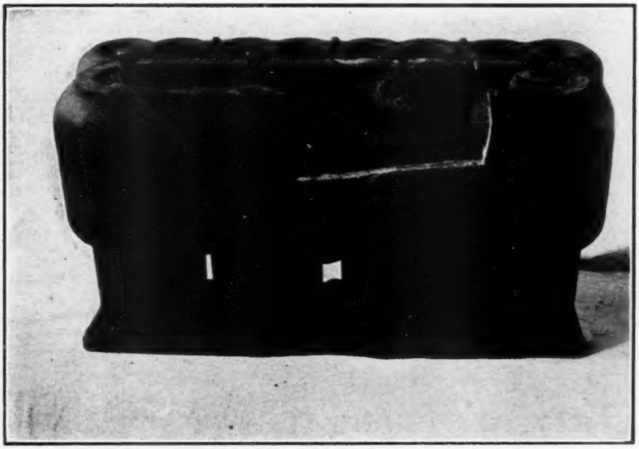


FIG. 11.

of the casting which was welded and protecting it with asbestos while the welding was being carried on.

Good welding is easy of accomplishment and involves no principles which are not perfectly well known in the foundry. In welding, due allowance must be made for expansion and contraction and also for oxidation as in any other fusion or casting process. The contraction and expansion of gray iron is readily taken care of by preheating and annealing, the value of which cannot be too strongly emphasized in this class of work. Preheating the whole part to be welded more evenly distributes the expansion throughout the entire casting, preventing unusual

strain in any part. This same principle applies after the weld has been finished—annealing will bring the entire casting up to an even temperature so that when it cools contraction takes place uniformly throughout the entire structure.

The most satisfactory method of preheating and annealing large castings is with charcoal and compressed air, principally because the casting can be left on the fire while the welding is being done. For small castings a burner using oil and compressed air is very satisfactory.

The flame of the welding blowpipe has no tendency to appreciably change the chemical composition of gray iron. The natural tendency of this metal to show a weld or a porous structure is easily overcome by the use of a suitable flux which cleanses the weld and prevents oxidation of the metal.

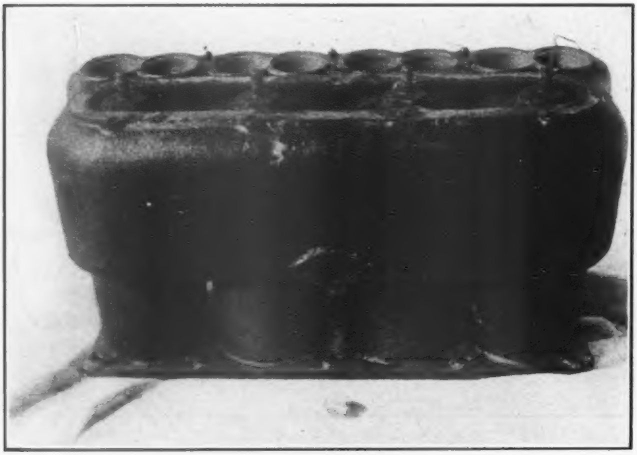


FIG. 12.

In fact, a foundryman's knowledge equips him better to weld intelligently than almost any other trade.

In cutting, the action of the blowpipe is so rapid that the heating does not, under ordinary circumstances, penetrate far beyond the edge of the cut and the metal is not seriously affected.

The metal immediately adjacent to a riser which has been

cut from a casting is soft and in good condition after the oxide has been cleaned away, which can be readily accomplished with a hammer and chisel.

The point which we wish to bring forth emphatically is the fact that the installation of an oxy-acetylene welding and cutting equipment is essential in the modern plant, and that its first cost will be absorbed by the daily saving gained by its use in a very short time, that with the use of perfectly well-known rules covering foundry practice and a little care in the manipulation of the blowpipe, welding or cutting may be done without any deleterious effect upon the casting itself.

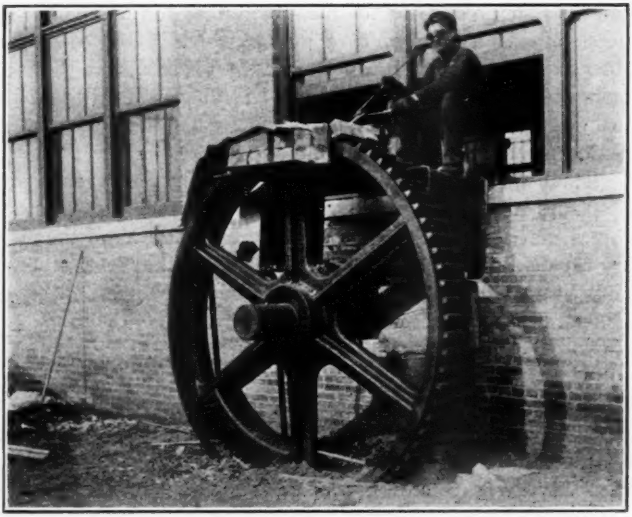


FIG. 13.

Oxygen Supply.

In conclusion, we will briefly mention three important factors upon which the success of the process depends, namely, oxygen, acetylene and competent operators.

When the art was first introduced to this country no adequate

supply of oxygen was available, and as oxygen is a most important element demanded by the process, this was indeed a serious drawback.

Oxygen was first generated chemically from potassium chlorate at a very high cost and with a low percentage of purity. This not only prohibited the process in many cases from the standpoint of economy, but also gave poor results on all classes of work because of the chemical effects of the flame.

After the failure of this method came the introduction of the liquid air process for the manufacture of oxygen, which produces gas with a high grade of purity, which is sold to the consumer at a low cost. It will be readily realized that these two distinct advantages, brought about by the new method of producing oxygen, almost completely eliminated the disadvantages existing before their introduction.

There are at the present time about six large oxygen producing plants in this country, and there are other new plants in process of construction. To take care of the requirements of this rapidly growing industry, it is safe to assert that before many years have elasped there will undoubtedly be an oxygen plant in every city of note in this country.

Acetylene.

Acetylene, the gas fuel which plays such an important part in the oxy-acetylene process, and which possesses the highest chlorific value of any gas, can be had in convenient form to meet practically every condition demanded by any working problem. It is usually generated in carbide-to-water feed generators, where small quantities of calcium carbide are added to large quantities of water (one gallon of water to one pound of carbide), insuring cool and safe generation. Generators may be had which in design and construction meet all of the requirements of the proper standards of safety set by the insurance interests.

Calcium carbide, from which acetylene is generated, may be obtained at exceedingly low prices and the manufacturers have warehouses in every city of note throughout the country.

The only conditions demanded by the oxy-acetylene process which are not met by stationary acetylene generators are where the objects to be handled cannot be brought to the plant, such

as wrecking bridges, or structural work, scrap cutting, and in emergency welding, repair work, etc. In such cases may be substituted acetylene dissolved and compressed in steel tanks filled with the liquid hydrocarbon, acetone, which has the property of dissolving twenty-five times its own volume of acetylene for every atmosphere of pressure. By compressing the gas up to about ten atmospheres, a large volume of the gas is obtained in a very small space. These tanks are easily portable.

In view of what has just been said, it can be seen that these main supplies, oxygen and acetylene, can be obtained under most favorable conditions to forward the satisfactory and economical accomplishments and possibilities of the oxy-acetylene process. Labor has had a great deal to do with the so-far accomplishments of the process, and will have an equally important bearing on its future developments. Intelligent workmen have naturally taken a liking to this class of work and are very much interested in it. Large numbers are becoming daily more and more familiar with the most effective and economical operation of the blowpipe. Steps have been taken to encourage artisans to enter the field, and at the present time two large schools are maintained for the instruction of the art to workmen; one located at Chicago and the other at Newark, N. J. In these schools men are taught to apply the blowpipe economically and effectively to all classes of work.

Anyone attempting to forecast the future applications and possibilities of the process is limited only by his imagination. Its scope has widened so considerably since its introduction to embrace operations in every field of the metal working industry, from wrecking high structural work to welding delicate pieces of jewelry, that its past successes are the safest grounds for basing our predictions for its advancement in the future.

VITAL POINTS IN GOOD FOUNDRY PRACTICE.

By J. J. Wilson, Detroit, Mich.

In presenting a short paper on this subject I hope to impress on you some of the things we are apt to overlook, and its aim is to bring out some discussion on ordinary foundry troubles which the scarcity of papers on the subject would indicate us as loath to air our troubles before our associates. The following of such a course, however, I believe would result in a benefit to the general welfare of our members and it would further seem that this is the occasion to bring up such matters.

The first essential to a successful foundryman is of course a thorough knowledge of the business. This is especially emphasized at the present time by the change in labor conditions as existing twenty years ago to those confronting us today. Then skilled labor was commonplace; now it is the exception. The executives of the business are the mechanical brains, for to use foreign labor now generally employed in foundries, patterns must be so constructed, and so many devices added to facilitate the molding that almost any illiterate foreigner can be taught to use them and produce good castings within a short time. Ability to judge the quality of raw material such as core and molding sands, and all of the smaller supplies is a most necessary requisite, for many times great losses hinge on mistaken judgment as to the suitability of the material used for the work at hand.

The second essential involves thorough knowledge of the game we are playing in all of its branches, that is a complete familiarity with the processes of the core room, the foundry proper, the mixing and melting of metal, and the cleaning, testing and inspection of the castings. This means that one must keep up to date with all the advances in foundry practice in general. It also means association with our neighbor and exchanging ideas with him; attending the conventions and taking advantage of the papers presented. In our line of work things change rapidly and the

foundryman is now often called upon to judge of the practicability of a new design, and a wide knowledge of modern methods is invaluable.

The third essential is a capable organization. The foreman and assistant foreman must be trained to handle the class of labor which is available. The qualifications of a modern foreman must be broader than formerly, for he must be a good teacher as well as an executive. The old time practices cannot be followed where molding machines are used with any success. Under present conditions patterns may be plated, gated, jar rammed, rolled and drawn by mechanical means, and if cores are to be set, jigs can often be devised for the locating so that the whole operation is almost fool proof and requires little more than a routine of simple operations easily taught the laborer. Such instances require but little instruction from the foreman, but they are the exception, for in the most part they cannot be simplified to such an extent. The personal equation of the workman enters into the case materially. If the ramming be too soft the casting may swell, which besides requiring more machining may throw the locating points off to such an extent that it is only fit for the scrap pile. If rammed too hard we have other troubles in the shape of scabs and blows. If the bottom boards are not bedded properly we may have distorted castings. If gauges be required for setting cores, one must be sure that they are used and used properly. In short, it requires much patience and constant effort to drum into the laborer the necessity for his following directions implicitely and paying strict attention to the small details.

Such an organization as referred to above must have harmony between the foremen of all departments in order to secure the successful operation of each department. The superintendent by the use of a little diplomacy can often eradicate petty jealousy and lack of cooperation between department foremen, and without the latter the balance sheet may be on the wrong side. A good executive will not neglect those matters which may seem trivial but at the same time are all important to procuring the end in view, *i. e.*, good castings and increased production.

The cooperation of the departments allied to the foundry is essential; that is, the pattern and machine shops. The need of the close proximity of the pattern shop is so self-evident that it

requires no comment. Frequent consultation between the foundry and pattern shop on new designs is necessary before pattern equipment is made in order to arrive at the best and most economical method of production for the foundry; unless this is done it frequently means that the pattern equipment must be entirely changed or made anew.

From observation I feel positive that some of the foundries do not maintain a good cost system. I believe in one. It can be effective though simple; a foundry should not take work from a customer at a loss. This has been done repeatedly in the past, and is being done now. Later they wake up to the fact, considerable business has been done, but profits commensurate with the amount of business transacted are not forthcoming. Then perhaps follows reorganization or failure and a waking up to the necessity of "knowing" things. The standard cost system recommended by the American Foundrymen's Association a few years ago I have found to be very effective, simple and applicable to any foundry. In short, a cost system should not be so elaborate that it will cost more to maintain it than the profits will amount to.

The final word as to the reputation of the foundryman is that he should aim for *quality*, and to get this, rigid methods of inspection and testing of castings are necessary. A reputation for *quality* will often get business at a higher price than the foundry producing mediocre work at a lower price. That is to say, if the foundryman were to forget the matter of profit for a time and give his entire attention to raising the quality of his product he would soon find that he would reap the benefits of his seeming sacrifices in that he would have all the work he desires at his own price.

TESTING MOLDING SANDS AT WENTWORTH INSTITUTE.

By Edw. A. Johnson, Boston, Mass.

A thorough knowledge of the materials used in the production of castings, and especially of the molding sand which is used to make them, is so important that no foundry can be considered up-to-date and abreast of modern progress if it is not equipped to make accurate comparisons and render right judgment in matters of this kind.

It quite often becomes a serious problem to determine with certainty what kind and grade of sand to use on a particular job to get the best results, and in many cases failures are made because the molder assumes that all molding sands should be treated just alike.

Experience has shown that the percentage of failures in very many cases can be greatly reduced and that in consequence large economies can be made by having accurate knowledge of the exact properties of the different molding sands that are available; the degree of ramming that each sand requires for a given type of work; the amount of venting that each sand needs; its ability to withstand scouring, fusion, scabbing and the like; the amount of facing that it will safely carry; the amount of gas that it gives off and the relative quantity of water that it requires as compared with other sands to give the best temper for different kinds of work.

Where the work is of varying and miscellaneous character, as in the average small jobbing foundry, accurate information of this kind along all of these lines is not so essential as it becomes when the work is standardized and done on a large scale and when the competition is keen.

Let me give an illustration. I know of one particular job which was being done on a jarring machine in excellent fashion.

The work was thoroughly standardized, care and attention had been given to the patterns in order to reduce the time at that end to a minimum, and it was requiring thirty jolts for each mold. It was felt that the job was costing too much, so an investigation of sands was made; and another sand was found of somewhat coarser grade and stronger bond which gave just as high a percentage of perfect castings with but twenty jolts to the mold. You can appreciate the reduction of time which this simple change effected and the consequent saving in the course of a month on each one of the jarring machines in the plant. This incident illustrates just one of the many phases of this complicated question.

I could give a second illustration which has recently come to my attention in which there was not only an even greater saving in time than in the one that I have just referred to, but in which there was, in addition, a great reduction in bad castings and failures because, when just the right sand was used, it was found that twenty jolts produced a mold which vented so freely and perfectly that trouble from scabbing and cutting was eliminated and the other losses were reduced to almost zero percentage.

I could go on and give illustration after illustration to bring out the many other phases of this problem of selecting proper sands; but enough has been said to forcibly call the attention to the two points that I wish to make clear; first, the very great importance of this question of *Testing Molding Sands*, and second, the many-sided character of the problem.

Recognizing these things, Wentworth Institute has wished to send out into the trade men who have had special training to cope with these difficulties, and consequently it has established in its Foundry Department a special course in *Testing of Molding Sands*, a brief description of which I believe would be of interest.

This course begins with some preliminary instructions on such matters as the principle of sedimentation and the way in which moving water in streams and on the shores of lakes affects the character of sands, the influence of rain, ground-water and wind, and other questions of this kind.

Second.—There is a careful study of the types of sand to get the student familiar with the materials that are available and to get them to appreciate such differences as, for example, the difference between a rock sand resulting from sandstone forma-

tions and a glacial drift sand derived by assortment of glacial drift material by wind and water currents.

Third.—Sands are carefully studied with reference to the minerals that they contain in order that the student may have some scientific basis for his subsequent studies. We separate out the quartz and the feldspar, the mica and the dozen or more other principal minerals that enter into these sands and let the students study these constituents by themselves, both with the naked eye and under a microscope in order to give them an appreciation of the influence of an excess or too small a quantity of any one of these different elements.

Fourth.—We teach the student how to analyze the sands, showing them the process for an accurate ultimate analysis, and also the methods of the approximate rational analysis.

Fifth.—We give them the simple practical test for determining the clay bond by means of the familiar aniline green dye. This test, of course, is empirical and only approximate, but is very simple and the relative results obtained from it are very useful for comparison. It is, too, a test that any foundryman can make in a few moments with any sand and without the aid of special laboratory. Also for purposes of simply comparing one sand to another as, for example, in determining whether a new shipment is identical with the previous shipment, no single simple test that I know of indicates more than this test for the clay bond.

Sixth.—The students are given the methods of determining fineness identical with those described in the American Foundrymen's Association Tests and contained in Volume XXI of the "Proceedings." This fineness test is also a simple test that every foundry should apply to every shipment of sand.

Seventh.—The students are given the opportunity to study sands carefully under the microscope, both in their natural condition and after they have been thoroughly dried, and are taught how to detect from this microscopic work differences that are likely to be of practical value in a commercial way. We keep practical shop tests on the molding floor running along parallel with these microscopic observations in such a way that the student does not get the two sorts of ideas separated in his mind.

Eighth.—The next test is the permeability to air. The apparatus used is very similar to that devised by the committee

of this Association. The tests are made in very much the same way with one important difference. Your committee, in describing its permeability tests, made them all under the conditions of constant air pressure and constant ramming. But as a matter of fact in commercial conditions in the foundry, the pressures of gases which have to escape from the sand vary from different classes of work, from very small pressures to very great pressures, and the facts that we should know regarding every sand, are what rate of flow of air may we expect when the sand is lightly rammed, when it is rammed to a moderate degree, and when it is very closely packed; and all under a great variety of air pressures. The tests that we have designed are intended to include all of these points.

Parallel also with these permeability tests which are conducted in the laboratory, are practical tests on the molding floor to determine the actual tendency to scabbing and blowing for different classes of work, light, medium and heavy, which corresponds to the different degrees of permeability determined in the laboratory. Throughout both of the laboratory tests and the shop tests, three degrees of tempering are used.

Ninth.—The Transverse Strength of molding stand is studied under the three standard conditions of tempering as recommended by your committee, and also under different standards of ramming and with different sizes of specimens. It is felt to be important in studying the tranverse strength of sand to include these two last points.

Tenth.—In similar manner we have felt that the Crushing Strength should be determined for small specimens and delicate loads as recommended by your committee. But in addition to these there must be tests on large specimens and tests on specimens rammed under different pressures.

Eleventh.—In addition to the foregoing tests we are planning others which appear to us of great practical value. An accurate determination of the volume of gas produced by a given weight of sand when burned almost to the point of fusion is important and should not be omitted. This is almost as important as its permeability.

It may be determined experimentally in the laboratory for comparison of different sands; but it should also be determined

in a practical way on the molding floor by measuring the volume of gas given off from a green sand core of standard size.

Twelfth.—The fusibility of sand is of the utmost importance to the practical molder and should be determined. Of course we can form approximate estimates of this property from our ultimate analysis of the same and our knowledge of the minerals that it contains, but we must not rely on this alone. The fusion test is made both in the laboratory in platinum crucibles, and also in a practical way in the shop by using patterns of a variety of sizes and determining what weight of casting can be poured at three different temperatures without causing enough fusion to create objectional scale on the castings.

Thirteen.—Sands vary in their ability to carry facings, some being much more satisfactory than others in this respect. We have planned a series of tests to determine the quantity of facing which each sand will carry when using patterns of three sizes, corresponding to an average standard of light, medium and heavy work.

Fourteen.—No test that we have included in our course is of greater practical importance in increasing efficiency in commercial work than our tests to determine the degree of cutting and washing in different sands when exposed to metal at different temperatures, flowing over it at different rates, after it has been rammed to different degrees of hardness.

Fifteenth.—In our description of all the foregoing tests it has perhaps been assumed that we were dealing exclusively with samples of new sands, but such is not the case. Of course, we require tests of this character to accurately guide our judgment in purchasing. But they alone are not sufficient. To put our tests on a thoroughly practical and commercial basis we must continue them still farther and determine the permeability and tendency to scabbing and blowing, the transverse strength and crushing strength, the volume of gas produced and the fusibility, the tendency toward washing and cutting, not only when the sand is new, but also after its strength has been reduced by burning. Tests, therefore, are made on new sands and on burnt sands which have been used in standard flasks with standard patterns and poured once, twice, three times, four times, five times, and six times. Each sand in this way is tested to determine how rapidly

it loses its strength and value and what percentage of new sand must be added at each heat in order to have it retain its properties constantly.

In endeavoring to increase shop efficiency in cases such as those illustrated by the examples that I gave at the beginning of this paper, tests on new sand would be no guide. For such purposes it will readily be appreciated that tests must be continued to the point where the sand has become burned to a degree of average commercial shop conditions.

PROCEEDINGS OF THE CHICAGO CONVENTION.

OCTOBER 14, 15 AND 16, 1913.

The American Foundrymen's Association, The American Institute of Metals and the Associated Foundry Foremen, met in joint session on Tuesday, October 14th, at 10 A. M., President H. D. Miles, of the American Foundrymen's Association, in the chair.

PRESIDENT MILES:—The meeting will please come to order. We have with us this morning as guests, our hosts of Chicago, and I take pleasure in introducing the Chairman of the Chicago Convention General Committee, Mr. C. A. Plamondon, who will take charge of the meeting temporarily. [Mr. Plamondon takes the chair.]

MR. PLAMONDON:—*Mr. President, the American Foundrymen's Association, the American Institute of Metals, and the Associated Foundry Foremen:* I feel highly honored in having been chosen by my fellow foundrymen of the Chicago Foundry Association Committee. I assure you that I am glad to be a foundryman. When I look at the splendid body of gentlemen here, representing one of the greatest industries of our country, it is gratifying indeed to see so many busy men who have left their business to come here to gain knowledge and wisdom from the learned gentlemen who will address these sessions. Our Entertainment Committee have provided some entertainment which we hope you will all participate in and enjoy, especially a little recreation in between your sessions. We are rather disappointed in not being able to have the Mayor of our city present with us today to extend to you a welcome, but we have with us the Hon. William H. Sexton, Corporation Counsel of the City of Chicago, who will represent the Mayor and extend to you, I am sure, as hearty a welcome as the Mayor could have extended if he were present in person. Mr. William H. Sexton, Corporation Counsel of the City of Chicago. [Applause.]

ADDRESS OF WM. H. SEXTON, ESQ.

Mr. Chairman and Gentlemen of the American Foundrymen's Association, the American Institute of Metals, and the Associated Foundry Foremen: As Mr. Plamondon has said, the Mayor of Chicago, Carter Harrison, has been unable to attend the opening session of the convention. His inability to attend, however, gentlemen, is my good fortune in being permitted to address you on this occasion. The work of your association, it seems to me, is epitomized by the few words which appear on the first page of your printed program, and I would not undertake to state it better than it is there stated:

"Out of the molder's sand much of the wealth of Chicago has sprung. The progress of the molder's art and of the apparatus with which he plies his trade is reflected here in architecture and in industry. To foster this progress is a privilege. In this common purpose Chicago extends greeting and welcome."

Why, gentlemen, I do not know who wrote this, but it seems to me that it epitomizes, in portion, Chicago's great progress. This convention is now being held on the nineteenth floor of a great sky-scraper in Chicago, and Chicago was the birthplace of the sky-scraper. Without the molder's sand, Chicago would never have risen to the position it occupies today, that of the fourth largest city of the world. I congratulate you, gentlemen, in your laudable pride in being identified with the art of the foundryman. I extend to you, on behalf of the Mayor of Chicago, his personal and official greeting to you, and I hope and trust that your stay in Chicago may not only be as beneficial as your program indicates it will be from the character of the papers to be read here, but that you will enjoy it from the social standpoint, and that you will have opportunity of visiting in and about Chicago and learning of Chicago's greatness. I trust, ladies and gentlemen, that if occasion offers, and perhaps it may, if you exceed the speed limits of the city, in your travel in Chicago, that we can be of some little service to you from an official standpoint; and if anybody becomes too zealous in the enforcement of some of these minor laws in Chicago, I hope, through your Chairman, you will call on me and perhaps I can do something to minimize your temporary embarrassment. I trust you may have a successful convention, that your stay here may be pleasant, and that when

you arrive at your respective homes you will find things in a pleasant condition there. You are welcome, thrice welcome, ladies and gentlemen. [Applause.]

Mr. Plamondon:—The Association of Commerce has made it possible for us to have this convention here. They have been zealous in looking after the details and seeing that this committee was properly formed, and we have with us one of our leading citizens of Chicago, Mr. E. C. Ferguson, who will address you on behalf of the Association of Commerce. Mr. Ferguson, ladies and gentlemen. [Applause.]

ADDRESS OF MR. E. C. FERGUSON.

Mr. Chairman, Ladies and Gentlemen: On behalf of the Chicago Association of Commerce, representing the vitalized force of the business men of this city and having an interest in the organizations which are jointly represented here today, I, as one of the members of that body whose duty has been so designated by the organization, to extend to you Chicago's hearty welcome on behalf of the business interests of Chicago, now welcome you most cordially to our presence, and we appreciate the fact that we have been a factor in bringing to Chicago these splendid organizations, organizations that represent one of the largest industries of this western country and one from rank and financial standpoint, representing about the largest industry, the iron industry, that we have in this section of the country. I had the pleasure of having sent to me by our Congressman, a report of the statistics of this section of the country recently, and in perusing it I was simply amazed at the standing of the iron industry in this part of the country.

We feel proud to think that our organization has been a factor in bringing you into our midst. We believe that in this great center of the world's industry that it will be as beneficial to you as it will be helpful to us to have had you come here, and I simply want to call your attention to a few things which I think of at this time, as an advocate of certain ideas. I want to say something to you, as I feel that we all, in addressing each other in convening in these great conventions every man should have a message to carry to the other members and something to

carry home to his people. I want to say to you—I want to halt you for a moment, to think of the great growth of your own welfare and the city in which you are holding this convention. We all know of the rank of Chicago. There is not a man in the United States but who is proud of her growth; but when we think that all of this grandeur which you represent has come to us in so short a time, it behooves us to meditate in our deliberations and turn for a time possibly to the sentimental side of business to soften its hardships and to bring mankind closer together; because you know that the first white man who ever visited this section of the country, and came either by way of the St. Lawrence, the Mississippi, or across the Alleghenies, came here in 1673. It has only been as far back as 1689 that the first flag of commerce was raised in the land west of the Allegheny mountains and south of the Great Lakes; and here, in that short time, you are here hoisting your flag and proclaiming your welfare and your doctrines.

When I think, for a moment, that it has only been since 1818 that steam navigation first commenced on the Ohio and Mississippi Rivers, when before that the canoe, the flat-boat and the stage-coach brought here such little industries as are today represented by your big business, there is no use of my talking of the other details. But when I think that the iron horse first entered the city of Chicago only in 1850, when the first railroad in Illinois was built in 1837 from the head of navigation of the Illinois River over to our present state capital. When I think of the tonnage of this great city and then compare it with that of our canal which runs down here, known pretty much as a tadpole ditch at the present time; yet it is only in 1846 that the first canal-boat came into Chicago—up to that we used to bring it by Desplaines River and by portage into the Chicago River. I only emphasize all this to carry out the point I want to make, that today Chicago is the playground of the world.

I want to say that we welcome you not for what you bring to us, but we welcome you because of whom you bring. There is a bit of history that I think this organization has reason to be greatly proud of, and we, as people either native or adopted sons of Illinois, are greatly proud of, and that is the fact that the first iron that was ever heated by bituminous coal in the United States

or in North America, was heated in the State of Illinois about 1681; so that it is not very long ago since this industry started in its simple form in the State of Illinois, down at Fort St. Louis, at Starved Rock. If you will study the early maps and surveys of Illinois, the carbon coal or carbon country as it was known, is first designated, and the first coal burned in America was burned in that locality in this state. So in coming in contact with your organization, we in Illinois have a common feeling, a pride, an interest, and a historic connection with this organization and its allied industries and all its people.

I want to say to you in this connection that I have had the opportunity of my life in my work with the Association, taking my time away from my profession simply because I believe that every man owes something to his state besides working for dollars which may be subject to taxation, that he owes a part of that unearned increment of his own welfare and his own fortune, that he should devote some time and some of his life for the welfare of mankind and for the benefit of the state in which he lives. With that purpose in view and that thought in mind I undertook to appear before you and appear before so many organizations of this character, simply because I will take the time to work.

Now I want to commend you for the great exhibit that you have gotten down here, and which to my mind exemplifies the highest effort that these organizations can put forth in the development of the thought which they bring as messages to their members. I have visited lots of these conventions and find that the most successful ones are those which not only exhibit the thoughts of men but also exhibit the practical and the operative work of the hand of man, and that is the benefit that is coming to you from the great exhibit which you have down in the pavilion in the southern part of the city. I want to commend your foresight, because that is the living monument of the mind and the development of the work of the men connected with our organization.

I want to say this, that the fact that you gentlemen are working here together in three organizations is an exemplification of the highest type of co-operative work. It means that the foundrymen, the employer and the employee, as a class, are coming together. It means that there is not only an effort here

for development, but there is an effort for the molding of a higher mind, of a higher development in the three great divisions into which your business seems to be divided, and it is one of the most commendable things that I have witnessed for some little time in connection with the convention work. Co-operative work is the great question of the day, and I want to say that there must be a continued awakening on the part of the business men, because if you do not take the leadership in the civic and business questions of the day, some other thought will lead you to an abyss from which you never can recover.

America has awakened; it is awakened in such a way that she never has known in all the history of her former existence. The power of men to think and determine, to settle the great problems which have grown out of our early pioneer life now into a settled development, not of things, but the settlement of men, and we have outgrown the old pioneer days, we have spent our energy and our time and money in developing the land and developing the materials and the earth's blessings into such things as you may; but the time has come when that early pioneer among the material things has, in fact, passed away. The subdivision of scientific devlopement and the by-products of old raw material have so enhanced the value of all these things, and advanced the standing and the mentality of men, that we have now reached a point when we are struggling in the pioneer development of men, and the pioneer development of society, and the pioneer development of the things that are going to make business prosperous and more successful, and overcome some of the problems of which I need not speak.

Now are you, as an organization, coming here not only to help discuss the material things, but are you here to help advance this higher calling among men, and the higher calling in business life. The value of these conventions is emphasized in what I have said is our great city, where we have had within the last year or two an average of one convention a working day, and the thought and the spirit that this great aggregation of mentality has inspired within this city, the impetus that it has given to men, and the determination of men to go on in its development, and the amelioration of not only the business men's troubles but the working men's difficulties and the difficulties lying between

them—I believe that Chicago and the Chicago men, and the men with whom they come in touch have reached a sphere of action and a momentous condition which is going to help to develop a higher and better condition of things.

We are the city in which the convention spirit and the congress of business had its inception; at the World's Fair there were more conventions and organizations developed and organized than at any other period in the existence of this country. I had the pleasure about a year ago of seeing this exemplified in the National Congress of Applied Chemistry which was held at Washington. We subsequently brought about two-fifths of the delegates at that convention out to visit our city. There were men from every known land of the world, and in the meetings of these men I was greatly impressed with the fact that every nation which is a representative nation on the face of the earth passed by in the reception that was given to those who composed the body that night. And to think that, since 1893, that great spirit which was inspired here and which the men inspired that came here, should have developed such a wonderful organization that men from all parts of the world were willing to come to the capital of our nation and there discuss the scientific questions of the day. Now these, as I speak, are the momentous and progressive questions and conditions which confront us, and I believe, just as truly as is exemplified in the great proposition which was developed at London at the Medical Congress held there this last year; when it has been scientifically developed that, from the time one is infected with cancer, that exactly within thirty-nine days from the day of infection there is an absolute deterioration and infection of the entire body, and if you can challenge or alleviate that infection within that thirty-nine days, you have got a chance to save the individual. Now that same principle of medicine, of physical condition, permeates everything in life and everything in your business, and you have got cancer spots in your business and cancer spots which you are going to discuss here, and others are coming. Now take those questions, discuss them fairly as men and see if there are any yet that are just new infections, and take hold together and see if you cannot stay and change the whole situation of some of those things within the thirty-nine days before the infection goes too far.

There are lots of things about business that are a delight, but business, gentlemen, is not all there is to this world. I love work; I was born in a city and raised on a farm, raised to work from the time the stars quit shining until they were shining bright at night, and I tell you the job of a man's life is systematic work. The old pioneer day of working before sunrise and on to sunset must pass away, both with the employer and the employee, the women and the children. There must come a proper organization of all those exertions of life so that there may be the greatest amount of results with a minimized exertion of industry.

Now my position, to bring it to you closer, is that from the forum of the intelligent business men we are due now to propagate a doctrine of conservation and conquering of the forces which must bring about the humanizing of existence. The labor people have agitated these questions until they are far ahead of the business men. Their questions are better known by their own clan and class than the problems of business are known by your clan and class, and it is time for the business men, not because of their wealth or a desire to curb or restrain the proper efforts of mankind, but it is time for the American business man to quit marking time and try to get the other classes of people in accord with the better welfare of our country so as to set and bring the mentality of these other people into a better accord of employer and employee. Now the world demands efficiency, and I believe that the business men are entitled to fair play. I believe that price agreements are valuable and justifiable when they are not arbitrary; so that you will judge from my position of mind that I believe in fair play among all of them; but the world demands efficiency, and the only way that men can produce efficiency is by greater contact with each other.

Gentlemen, as the wind carries the pollen from flower to flower so that the male and female flowers are fertilized, so that they will fructify, and the more the bee works among the flowers the greater the pollenization and the better the fruit that flowers, and trees produce, so it is with men; we have got to pollenize each other by the contact of our thoughts, present our thoughts fairly to each other, receive them liberally, interpret them fairly and get the best benefit and fruit from them. Now, when you start out this convention means nothing more than the polleniza-

tion of the minds of men. Your business typifies many beautiful things of which I cannot take time to speak because I have spoken now longer than I probably should, but when I think of the producer, the foundrymen, the molding—the molding of things and the molding of men is so synonymous of your business, that a man, if he wanted to preach a sermon, could preach for an hour on how your business typifies the great endeavors of men and things. I hope that you will bear in mind that in your business you are one of the oldest exemplifications, not only of the molding of things, but the molding of men. Why, I see by some of the stones or a tablet that was brought from Babylon to this country recently by long and strenuous effort on the part of the professors of the University of Pennsylvania, it has been discovered that on the brick brought from the city of Babylon there is the old plough and seeder protrayed in one of those tablets of brick, so that the invention of the plough goes back to 4,000 years before the time of Christ.

The molders of those days were working in their business in the molding of brick just as you are molding things today. Now it is with that spirit that Chicago sends me here—her business interests—to welcome you, and if you can find no nobler spirit—if you can find any more generous spirit, I would like to know of it that we may cultivate it. I believe that you have for your lesson and for your message, as I have said before, the molding of men, the building up of men for your business, the building up of the scientific qualities of your business, finding out the greatest and the best that can be done; then, beyond that, you have the beautification of our city. You have it within your power to mold for us, for our view, and for the view of generations to come, such men as our man Grant in Lincoln Park. Your handiwork is shown in the great monuments of Abraham Lincoln in our parks. Your handiwork is shown in the beautification of our city and in the statue of Drexel in the South Park, and other beautifications of that character, and the lesson which you can carry to men for all time to come is exemplified, gentlemen, in the monuments of great men throughout the world. It is with worthy pride that you have an organization which not only molds men who were as the Grecian runners in days of old, but from the Grecian runners you have molded, you are building and must

continue to build, no longer runners but gladiators, men who stand for things, men who are not gladiators to crush down business or crush out life, but gladiators who are inspired with the good things of life, who inspire men to life, to do things, to help men and lift men up and help them to aspire to the greatest and best things that God or humanity could give them to do. [Applause.]

Mr. Plamondon:—I would like to call your attention to the list of committees here printed in the program, and at the same time express to the Chairman and members of various committees my sincere thanks for their great help and the work that they have done in bringing this convention here. Mr. Cole Estep, as secretary, has worked hard and faithfully, and will be at his room on the nineteenth floor of this building all during this convention. Mr. Galligan, Chairman of the Finance Committee, is doing some wonderful work, and Mr. Carter, of the Entertainment Committee, has also worked hard, and he and Mr. Francis, of the Reception Committee, will be in attendance here during the entire convention and will be pleased to serve you in any way possible and make your stay in Chicago as pleasant as possible, and attend to your wants in every way. Then we have the Ladies' Committee, of which Mrs. Pridmore is chairman. She will be here, with members of her committee, all during this convention and will be glad to serve you; and we have Mr. O. J. Abell, who, as Chairman of the Publicity Committee, has given a great deal of his time and attention to this convention. I would like to call on Mr. Abell for a few remarks on behalf of his committee. Mr. Abell. [Applause.]

ADDRESS OF MR. O. J. ABELL.

Mr. Chairman and Gentlemen of the Foundry Associations: It is my privilege, in behalf of the local committee, to add to the greetings you have already received, a brief but very sincere word of welcome. Throughout our anticipation of your coming the thought has predominated that, between Chicago and your societies, there is a bond of special interest and strength. Twenty years ago the first organization of foundrymen in the West was held at Chicago. Twelve years later that gathering, grown into a national organization, met here again, and

now you come to the city where the foundry industry is larger than in any other locality. Here we have, in variety and in tonnage, the greatest assortment of castings produced anywhere in the world, I believe. A pleasing coincidence is also added to this occasion in the fact that our Chairman today was the chairman of that original organization twenty years ago. Since that time and since the meeting here twelve years ago, many new faces have appeared in your organizations here and in your organizations in all the other cities, but they simply have in them a promise for the impetus to greater endeavor and larger things. Chicago, it has been said, is a great and wonderful city. To those of us who live here it has had a wonderful inspiration. The best the committee can wish for this meeting and the other meetings is that they gather something of that Chicago inspiration, something of the enthusiasm and determination to excel.

There are one or two announcements that do not appear in the program, to which I would like to call your attention. Tomorrow noon, immediately following the morning session of the meeting, there will be given to the men in attendance at the several society meetings, a buffet luncheon to be held in the south room on this floor. Every one who can come is cordially invited to attend. That is on Wednesday noon, and immediately preceding the matinee at the LaSalle Opera House to which we will go directly from this buffet luncheon. The ladies are requested to be promptly at Marshall Field & Co.'s at 11.30 on Wednesday. I am also asked to call your attention to the complimentary matinee at the LaSalle Opera House tomorrow afternoon. It will be necessary that both ladies and gentlemen have their tickets with them so that we can accommodate the people whom we particularly seek to entertain.

I also want to speak a word for all of the things that our Entertainment Committee have arranged for you; I speak this, not in behalf of the Entertainment Committee, but in the interest of your own meeting here. Only by the attendance of everyone at all of the meetings and at all of the things that are being done, can you go away with a feeling that the meeting has given you all it should give, and I therefore ask that, in the two or three days you are here, the first thing in importance in your minds shall be those things regularly arranged for you to do.

I certainly hope you will have a good time and go away with the fondest and pleasantest recollection of Chicago. [Applause.]

MR. PLAMONDON:—I thank you sincerely, gentlemen, for your kind attention this morning and will now turn this convention over to your President, Mr. Miles.

President Miles takes the chair.

PRESIDENT MILES:—It has never been my pleasure to listen to more able welcoming addresses, and I am now going to call on my good Southern friend, Senior Vice-President Howell, of Nashville, to reply. [Applause.]

ADDRESS OF VICE-PRESIDENT ALFRED E. HOWELL.

Mr. President and Gentlemen: In responding to the address of welcome of Corporation Counsel Sexton and Mr. Ferguson, of the Association of Commerce, and in order that we may properly appreciate our welcome, and to realize by whom we are welcomed, it is equally proper for us to reflect a moment who we are to whom this royal hospitality is extended.

You see, when you get to Chicago, the city of such "cloud scratchers" and mammoth accomplishments in commerce, manufactures, education and art. Most of us fellows who come from the relatively little hamlets that dot the other states, have to keep pinching ourselves to hold in mind what our mothers told us—"Don't forget that you are a McGrill."

In 1763, by the treaty of Paris, the French government yielded to Great Britain all claim to land east of the Mississippi, and thus the Illinois country became British.

By the Quebec act of 1774, all of the newly acquired land between the Ohio and the Great Lakes was included in the province of Quebec, thus placing it under the military government at that time prevailing over Canada.

However, in 1778, Governor Patrick Henry, of Virginia, sent over troops under Col. Geo. Rogers Clark, and replaced British authority by American throughout the Illinois country.

The treaty of peace of 1783 drew the northern line of the new republic through the Great Lakes, instead of through the Ohio River, as probably would have been done except for Patrick Henry and Col. Clarke's victorious expedition, and thus the site

of Chicago became American instead of British. Were it not for this circumstance we would now doubtless be welcomed as guests by Prince Anthes and Earl Chadsey.

Virginia organized the Illinois country as a county, the County of Illinois, and under that government it continued from 1778 until 1783, when there came the cession of all the northwest to the United States.

Now you see where we are getting to. A good many of us here are Virginians (I am by parentage, both sides). Big as you are, we are your daddies and are glad to be welcomed to the home of our big, lusty boys. But this is not all. You remember the old song,

> "Rock the cradle, John;
> Rock the cradle, John.
> There's many a man rocks another man's son,
> When he thinks he is rocking his own."

We thought we were rocking our own.

Virginia claimed all the territory between the Ohio, the Mississippi and the Great Lakes on the ground mainly of conquest. But New York claimed the same territory on the ground of a treaty with the Iroquois, who claimed to have extended their conquests to the Mississippi. Massachusetts and Connecticut claimed under their original charters to own all the land between their northern and southern boundary lines of latitude, west of New York as far as the Mississippi.

So you see beside the Virginia claim we must admit the claims of New York and Massachusetts and Connecticut, and surely we have many representatives of these states here.

All in good nature surrendered their claims to the general government in 1783 and we can now exclaim with Goldsmith, speaking of the good Vicar of Wakefield.

> "Your house is known to all the vagrant train.
> You cheer their wanderings, and relieve their pain
> The reckless spendthrift, now no longer proud
> Claims kindred here, and has his claims allow'd."

But if the forebears of some of us were your wet nurses, you went through the fiery ordeal of 1871, when destitution for a

time fell upon you and was relieved with lavish generosity from all parts of this country and Europe.

If you had the interest of so much of the world then, how much more now that with giant strides you have eclipsed all other cities of the world in so many important respects.

"Upon what meat, doth this our Caesar feed, that he hath grown so great."

We shall see! Here we have gathered from all parts of our united country to eat with you, to hold converse with you, to catch your manners and partake your gale.

The American Foundrymen's Association held its first meeting in Philadelphia in 1896. (In 1900 we met here.) Out of it have sprung the American Institute of Metals, the Association of Foundry Foremen, and in 1906, at Cleveland, was held in connection with these, the first exhibit. The growth and progress of all are something to engage our pride, the expansion of the exhibit feature under the management of the Foundry and Machine Exhibition Company is truly marvelous. It is analogous, it seems to me, to the growth of the laboratories in connection with our great institution of learning in contradistinction from the old method of "a book and a bench" class room. The advent of the exhibition feature and its development into a living, moving, working demonstration of the labor saving appliances applicable to all branches of the metal industry has added very much to the importance of these meetings, the resources required to handle them, the broad base which elicits the interest of so many. May I venture to hope that the splendid co-operation which has wrought so grandly up to this moment, may long continue. Uncle Jake says, "a wise fox don' broke up a hen nest."

Now, gentlemen of Chicago, may I beg to say for the thousands who will attend this convention, representing interests possibly second only to the railroad or banking interests, that for your kind expressions, for your hearty welcome, we all from North, South East and West thank you most heartily, and petition the great powers that the sun may never set on the cargoes of good things that emanate from Chicago.

"Welcome ever smiles, and Farewell goes out sighing," and so shall we till we meet again. [Applause.]

PRESIDENT MILES:—The next order of business consists of the annual reports of the officers of the several associations in joint meeting at this session.

ADDRESS OF PRESIDENT H. D. MILES.

Members of the American Foundrymen's Association, Institute of Metals and the Associated Foundry Foremen: It gives me much pleasure to greet you today and rejoice with you over the strength of our associations and the excellent results which they have accomplished. We convene today in the second largest city on this continent, located in a district wherein are established many plants for the manufacture of iron and steel and the machinery in which such products are used.

The foundry industry here is very large and some plants represent the most modern development in the foundry art, notably the International Harvester Company, where I understand the highest attainment in molding machine practice has been accomplished.

Our practice of holding our conventions in cities in different parts of the United States and Canada stimulates interest, increases our activities and accomplishes the most far reaching results. It is in proportion to the interest we create that our membership increases and that funds are supplied for carrying on the work, and it is important therefore that we continue the practice of changing our meeting place yearly. Supplementing this, however, should be frequent campaigns for new members.

The officers of the American Foundrymen's Association carried on such a campaign this year with very satisfactory results. Our membership has been increased more than twenty per cent over last year, allowance being made for thirty-seven members who have resigned or were dropped for non-payment of dues. We now have the largest membership since our organization and our income for the year is nearly twenty per cent greater than for our best previous year. This income is exclusive of the generous donation of $500 given for our work by the Foundry and Machine Exhibition Company.

One of the difficulties we experience is a lack of proper interest by some of our members in the work we do and the help we offer. The managers of plants are frequently too busy with general matters to give the time to study the lessons we teach, and I would suggest as a remedy that each of these managers designate some one person among his employees, best qualified for the work, to attend to Association matters, read the articles we publish, visit conventions, and from the knowledge obtained report on betterments which it would be advantageous to adopt. While our work is educational, its purpose is commercial and the result should be expressed in increased earnings. Those members who serve as teachers do so gratuitously, and their unselfish work merits our thanks and our careful attention and study. It is a free school where much can be learned and we are not alert if we do not take advantage of the opportunities offered.

I would be glad to see more general interest taken in the discussion on papers read. Each of you should have some knowledge garnered through experience on some of the topics under discussion and should be willing to impart it even though you do not like to talk in meetings. We are here to help ourselves by helping others. I would be glad to see more work done by committees, problems studied and remedies determined. We should have a committee on standard foundry costs. This committee should have authority to employ a high grade expert to assist it, and after a proper system is prepared and adopted by the Association, every effort should be made for its general installation in foundries. Costs must be known before reduction in them can be intelligently made. Costs must be known before intelligent bidding can be done, and costs must be known if the percentage of failures is to be reduced. A proper cost system intelligently used is necessary to the efficient operation of a plant and to the correct determination of prices on products for sale, and the same general system should be used by all concerns in any one line of manufacture.

In any competitive field, it is the ignorant bidder who causes the trouble which leads to bankruptcy or monopolistic combinations formed for self-preservation. I believe that most monopolies were formed not for the purpose of making excessive and unlawful profits, but in order to secure any profit at all. It was

only after they felt the strength and security of their positions that combinations began to misuse their power. The day may come when governmental commissions will regulate all industries, determine costs and selling prices, and the number and locations of plants. When that time arrives, there will be uniformity if not efficiency, but until it does arrive, we must make the best use we can of such associations as this to establish reliable and standard cost systems and up-to-date and efficient methods of operation.

This Association some years ago formulated a system of costs, and distributed the information among its then membership. That time has so long passed and so many members have been taken in since that time, that it is important that the subject be again taken in hand and the most modern method worked out and made use of.

Other notable problems have been solved by this Association, but there is much yet to do, and we should have the will to do it and I solicit the aid of all members in the work. The new tariff laws are in effect, what the ultimate results is impossible to accurately forecast. That so radical reduction in duties will greatly alter conditions in some lines of trade can be safely predicted. The fact that our labor per day, per man, costs from two to three times what such labor costs in Europe means that our labor must be two or three times as efficient, working in conjunction with our modern shop equipment, as European labor is working with foreign plant equipment. This condition causes great anxiety among managers and owners of industries on this side of the ocean. Either our efficiency is the marvel of the age, or else our labor must be content with less wages if the present duties on some products are to be maintained. Our American optimism hopes for the best and will do its utmost to resist the worst, and this Association must do its share to suggest ways and means of increasing output and at the same time reducing costs.

I cannot close my remarks without expressing my sincere appreciation of the splendid work done by my good friend Dr. Moldenke. His technical education, his high sense of duty, his untiring energy and his wide and valuable acquaintance make him an ideal secretary for our Association. It was only by my close official connection with him that I am able to appreciate the

great amount of and the valuable work he has done and is doing. I want to express my cordial thanks to our vice-presidents, Messrs. Howell, Bull and Chadsey, for their assistance in the campaign for membership which was so fruitful in results.

I have enjoyed this year's work, and consider it a privilege to have been given an opportunity to serve you. You have a strong organization, and I have confidence in its future usefulness and success. [Applause.]

PRESIDENT MILES:—We will now hear the report of our Secretary, Dr. Moldenke.

THE SECRETARY:—*Mr. President and Ladies and Gentlemen:* I am particularly gratified in making my report to you today, because here, thirteen years ago, I was elected secretary of the Association and therefore I hold Chicago in very grateful remembrance. My report for the year ending June 30, 1913, is as follows:

REPORT OF SECRETARY-TREASURER RICHARD MOLDENKE.

Mr. President and Members of the American Foundrymen's Association: The last few years have been notable in the foundry world for the attention given to cupola practice. The work done by our Association in this direction, and the stimulus given to individual investigators here and abroad, has been such that today we may truly say that melting iron in the cupola is at last on a scientific basis. The idea that every cupola has its mysterious ailments and must be humored and prescribed for specially, is now exploded, and the foundryman knows that whether his cupola be big or little, whether run continuously or for a few hours at a time only, certain definite relations between volume of air supply, position of the fuel bed, and maintenance of melting at the zone of highest efficiency and temperature through small and properly distributed charges, are requisite in order to avoid all those troubles which castings are heir to even when starting with the highest grade of metal.

The office of the Association has been deluged with letters asking advice on every phase of the melting problem, and the discussion has been taken up abroad for very serious study, as is

evinced by the English, German and French technical press. We may therefore consider the year just past an epoch making one so far as the metallurgy of the foundry is concerned.

Two other matters stand out prominently in addition. First, the unusual demand for accident statistics, particularly the investigation made by our Association several years ago, the reports of which have been speedily exhausted. Second, the general feeling that standard cost accounts are highly desirable. The Standard System for Foundry Costs prepared for our Association by its committee of cost experts and efficiency engineers, is being revised and elaborated—so that it might be more useful to the individual members. This report was not quite completed in time for the convention, but will be distributed later on. With the radical change in the tariff in effect now, and the general feeling of uncertainty prevailing, it is quite patent to the thoughtful observer—particularly if he knows anything of the economies practiced in those countries which are certain to benefit by the change in policy—that we must prepare to use the knife on our cost items where heretofore we have been rather easy-going. This country does not realize how wasteful everything has been carried on, and it needed the jar of radical action to bring this home to us. It is to be hoped that we will not go efficiency-mad as a consequence, but rather that we study human nature, select men for their best work, use only quality factors in the make-up of our product, and see that the pound of iron goes further than ever before.

In the chase after commercial supremacy, the nations of the earth often sin grievously. We in America have our share to explain also. We have, however, a fairly good reputation for liberality in showing our establishments. This is not the case in so great a measure in other countries, and as we are consequently at some disadvantage in the race, occasion was had to enter a rather energetic protest during the year, when one of our valued members was excluded from establishments whose representatives had been liberally treated here. A circular letter was addressed to all the interested societies of the country, much correspondence had, and an almost general agreement reached looking toward liberality in showing our establishments only when reciprocal courtesy is promised. Since that time no one is given an

introduction from our office to the Membership until his promise to reciprocate by opening his own establishment has been obtained. Your Secretary has been bitterly assailed here and abroad as a consequence, but calm reflection will show that the man who comes to learn from us with the deliberate determination to keep his own knowledge secret may be very "smart" but is nothing other than an industrial pirate, to give it a mild appellation.

A situation that requires attention is becoming rather manifest in the foundry world of late if the good work of this Association is to continue. Editors of the great Trade Journals have noted the same thing. It is no longer possible to obtain a wealth of papers and discussions. The foundry as a subject—limited in a manner anyhow—is becoming too well threshed out, and while our more recent papers are not as crude as many examples of former times, nevertheless there are no more startling advances to herald or subjects to dig into readily.

It is therefore absolutely necessary to follow the lead of our large engineering and industrial associations, in creating efficient and representative committees on securing papers. Not only has the change from the regular Spring Convention to the Fall proved most disastrous in this direction, but the burden of gathering this material has become too heavy for your Secretary and the few fellow-officers who aid him in this work. When nearly three-quarters of the letters inviting cooperation from men able to write papers are not even given the attention of a reply, it is no longer a pleasure to try to provide a programme of wide range and good value. It is to be hoped, therefore, that willing hands will be found to help the good work along.

Attention is called to the uniformly kind reception accorded the annual volume of our Transactions. This notable book of nearly 900 pages seems to have greatly pleased our membership, judging from the numerous appreciative letters received. Since the expenditures of the Association for its publications, inclusive of the cost of mailing them to the members, amounts to about five-sevenths of the total income, it will be seen that very good value is given those who become members. It is a question whether any other Association of the size and importance of ours runs its affairs as cheaply as we do, and returns so much to its members in the way of publications.

It may be stated here that the call for back numbers has been such that we cannot supply very much more than the last two volumes of our Transactions, nearly everything else being out of print.

Attention is called to the extension of the periodical issue of the Membership List. In addition to such information of interest to the older members, as the convention places, former officers, etc., there is now given a Geographical distribution of the members as well as the Alphabetical List. These who are interested in building up the Association can now see at a glance how the several foundry centers are represented, and it is hoped will help to interest others sufficiently to join with us. It is a matter of congratulation that of the original charter members some sixty are still with us.

Thanks to the energetic work of our president, Mr. Miles, as also our vice-presidents, a large number of new members have been obtained, not only filling up the depletion in the ranks due to defections, but so augmenting them that today we have 760 members. We therefore have about ten per cent of the total foundries of the country, instead of ninety per cent as it should be. Only those who know how difficult it is to get men to help create instead of reaping without sowing, will realize that ten per cent is a very fine showing.

The finances of the Association are in good shape. The following are the items of income and expenditure:

FISCAL YEAR JULY, 1912, TO JULY, 1913.

Balance	$368.56	
Income	6,533.74	
		$6,902.30
Expenditures:		
Transactions	$4,361.16	
Salaries	1,200.00	
Printing	122.82	
Postage	677.00	
Convention Expense	436.09	
Sundries	3.40	
		$6,811.47

Balance left over $90.83.

The books have been audited by an expert accountant, and turned over to your Committee on Audit.

In conclusion your Secretary wishes to thank the members for their good will and assistance. This has enabled him to complete thirteen years of continuous service in happiness and contentment. That the Association may grow and continue its good work for the betterment of the industry is the wish of your Secretary.

President Miles:—As it was not possible for Mr. Olsen, President of the Institute of Metals, to be here this morning, he will deliver his address later, and we will now have the pleasure of listening to the Secretary of that Association, Mr. Corse. [Applause.]

Mr. Corse:—*Members of the Allied Associations:* The report of the Secretary of the American Institute of Metals is not quite as good in number of members as the good doctor's, but as we have occasionally reported increases of 25 per cent and 33⅓ per cent in former years, I think we may be excused in reporting a few less members than usual. Our membership this year has shown a disposition to mark time, which I believe is in line with the general industrial situation. On July 1, 1912, we reported 320 members. On July 1, 1913, which is the end of our fiscal year, 274. This is accounted for by the usual number of people dropping out through non-payment of dues, etc., and not replaced by new memberships. We have not instituted as active a campaign for new members this year as has the American Foundrymen's Association, which is probably the reason for this small decrease. At the present time we have a membership of 277.

[Mr. Corse then read his annual report, which is given in full in the Transactions of the American Institute of Metals.]

President Miles:—We will next listen to a report from Mr. Gale on the audit of the accounts of the American Foundrymen's Association.

Mr. C. H. Gale:—Herewith I present the

REPORT OF THE AUDITING COMMITTEE.

To the President, Officers and Members of the American Foundrymen's Association.

Gentlemen:—Your committee appointed at the last meeting of the Association to audit the accounts of the Secretary-Treasurer

beg leave to report having made the audit as directed and find the accounts correct.

Yours very truly,

WM. YAGLE,
C. H. GALE,
Committee.

The receipts, expenditures and balances that the committee found, have been given in the report of the Secretary, and I wish to say that we find the books of the Association kept in a most admirable manner, which greatly lessened the work of the committee in making the audit.

[Note by the Secretary-Treasurer:—The audit here referred to consisted of the Association books for 1911–12, 1912–13, and the Special Fund collected several years ago for investigation purposes (molding sand, etc.). Before turning over the accounts to the Auditing Committee and with permission of the President, they were first examined by an expert accountant, engaged by the Association, whose report accompanied the book to the Auditing Committee. It was deemed an imposition upon the time and good nature of the committee to turn over for their examination three years of accounts without this expert's report to aid them.]

PRESIDENT MILES:—I want to say, in connection with the income and expenditures, that there would have been a much greater difference or much more earning, had we not spent so much in our campaign for membership, in writing letters and printing and postage, etc. That increased our expenses, I should say, between $700 and $800, but I hope and believe that of the membership taken in this year, a larger part of it will remain with us. Better than it has perhaps been in the past where we have gotten large numbers at the conventions, who come here for entertainment purposes, and did not stay any great length of time. I hope that the new members we get will take an interest in the work and help us handle those problems that are difficult at present. I agree with the doctor that we should have an active committee on papers for the coming year, to relieve him. Besides, when one man constantly applies to the different members for papers, he is not as liable to be served at all times as a committee of three or more would be, especially if this committee was changing.

The next report will be from the Committee on Industrial Education, by Mr. Kreuzpointner, of Altoona.

MR. KREUZPOINTNER:—It is already 12 o'clock, and this afternoon Mr. Alexander will present an address on *Foundry Apprenticeship*. If there is no objection, I will postpone my report until this afternoon.

THE SECRETARY:—I think we had better have the report of the committee now, showing what has been done, and thus, Mr. Kreuzpointner, get it off your mind. Mr. Kreuzpointner, gentlemen, has just come from Winnipeg, where he addressed the people there on the subject of industrial education and got a special vote of thanks from them.

MR. KREUZPOINTNER:—Your Committee on Industrial Education has the pleasure to refer more particularly to certain conditions which are cropping out more and more distinctly, showing changes in our industrial situation. What your committee had particularly in mind was to call attention to the fact that we cannot take crops out of the social soil continually without putting something back in the line of intellectual effort and ability. If the foundryman uses nothing else but scrap, he will soon have to shut up shop. Western Canada is filling up with Americans who are leaving the worn-out soil of the United States to remove to the better soil of Canada. Likewise, intellectual ability cannot be farmed continually in industry nor in commerce, without replenishing it. Consequently, your Committee on Industrial Education begs leave to call attention to the fact that in the future more than in the past, efforts have to be made to not only retain but to increase the ability of our young people going into factories, even though they are unskilled men.

Where shall that ability come from? There is a universal cry for efficiency in all of our industries and human activities, and we have to use the schools, especially the industrial schools, for that purpose, or the minds of the young people will not get anything. Now, moreover, we have to deal with an immense number of people who are foreign to our institutions and yet who are destined by numbers to help to carry on our industries. Yesterday afternoon I passed through the most densely populated district of Chicago and on one news-stand I bought fourteen newspapers and thirteen of them were printed in foreign languages.

Just think of that! More than eighty per cent of the foreigners will eventually, and certainly in a short time, have to fill our shops, stores and offices, and we have to provide for those days.

Only a few months ago I had the pleasure of addressing a body of citizens in a Southern city, and I told them, "This morning I addressed the High School children, and found 1,005 of the flower of your youth there. You spend money lavishly for their entertainment, for their increase of knowledge and give them every encouragement to take an interest in your community and to make something out of themselves. Your superintendent tells me there are more than 1,000 school children want certificates at fourteen to sixteen and another 1,000 from sixteen to eighteen, balancing the 1,000 in the High School by more than two to one." I asked those gentlemen who were present and represented the citizens, and said, "Here on the one side you encourage 10 out of every 100 to do all they can for the community; you want them to understand that they are to carry on the life of this nation. On the other hand, there are two to one that you have not spent a single cent on; you have chased them out like a lot of wild sheep; you have set them adrift on the stormy sea of life without rudder and without oars. You give them continually to understand that you don't want or care to get out of them what little intelligence they have. How can you expect them to take an interest in your community?"

This, ladies and gentlemen, your Committee on Industrial Education is trying to solve, and we all have to work together. Here are thirteen newspapers in foreign languages and one in English. Last week I spent all the week in the city of Winnipeg, where they have a similar problem. The politicians are working up the foreign-born citizens to demand special teachers for their languages in their own schools. I passed one district, four streets in one direction and one in another and found only one English notice of a business, and that was a midwife. [Laughter.] That advertisement was in six different languages and only one was English. Ladies and gentlemen, I beg you to take with you and read our report. We must all work together.

In the city of Winnipeg one of the members of the school board asked me on the fifth day of my presence there, "What

weak points have you found in our school system?" He did not want me to flatter the schools, he wanted to find out what weak points there were. The Superintendent of Schools accorded your Chairman three full hours to talk over the situation. A special meeting of the teachers was called, aside from a formal address, and for two hours and a half the educational situation was discussed with an interest that I have not found for a long time in any city of the United States. Your Chairman was accorded a public vote of thanks for the help he has given the teachers and the authorities in Winnipeg during a whole week. Now up there they are straining every nerve in manufacture and commerce to get ahead of us, and they have certain advantages which we have to take into consideration. In the city of Munich 10,344 young men are forced to go to school continually who are going to compete with us.

These are only a few short points I wish you to lay to your hearts, ladies and gentlemen, and beg the support of all of you, of all the members of the American Foundrymen's Association, beg your support for your Committee on Industrial Education. In conclusion let me thank you for the support your committee has received during the year. [Applause.]

President Miles:—Mr. Kreuzpointner has devoted his life to the work on which he has addressed us this morning, and the Association and manufacturers owe him a vote of thanks and appreciation for what he has done and is doing. I am very glad he was so well received in Canada, as we knew he would be.

This afternoon we are to have an address by Mr. M. W. Alexander, of Lynn, Mass. Mr. Alexander is one of the leading men of the General Electric Company at that point, and his work on apprenticeship matters in connection with the General Electric Company, in the training of young men is, I judge, in a practical way, the most advanced of any in the world. I know that I have never heard of any other organization which has accomplished so much and had so strong a man in charge as Mr. Alexander. I have listened to his addresses on this subject on three different occasions and I enjoyed everyone of them very much, and I hope that none of you will miss his address, and I will be glad if you will tell any other members or people here who would be interested, to come this afternoon at two o'clock. Mr. Knoeppel will also

give an interesting address on *How to Make a Time Study*, following Mr. Alexander.

As there is no other business, we will adjourn until two o'clock.

SECOND JOINT SESSION. TUESDAY, OCTOBER 14TH, 2 P. M.

President Olsen in the chair.

PRESIDENT OLSEN:—The first business of this afternoon is an address by Mr. M. W. Alexander. Mr. Alexander. [Applause.]

Mr. Alexander then gave his admirable address, which was listened to with close attention, and which was richly illustrated with lantern slides.

The address and full discussion is published in another portion of this volume. At the conclusion of the address President Olsen (American Institute of Metals) introduced Mr. Charles F. Hatfield, field secretary of the Panama-Pacific Exposition, who spoke as follows:

ADDRESS OF MR. C. F. HATFIELD.

Mr. President and Gentlemen: I realize that time is flying and I am not going to take more than three or four minutes. I come here to extend the invitation for the consideration of your body, of the Panama-Pacific Exposition in San Francisco. To have you select San Francisco as a meeting place in 1915. I have talked with some of your officers and they do not know whether it will be possible, but we think the idea may grow as you understand the possibilities. Listening to Mr. Alexander's educational address, I am impelled to tell you that the exposition is going to be one of the greatest educational colleges that has ever been presented, and the vocational idea is one that is going to predominate. The exposition is not going to be simply a mass of construction and dead history, but it is going to be one of living issues, the things that are doing, of accomplishments. Its start is very properly of an educational character, because the exposition celebrates, as you know, the completion of the Panama Canal, the greatest engineering event in the history of the world.

At the exposition they are going to give you something new. It is not going to be the old-time hard view to the eyes, but the

Comptroller recently issued a statement (and he is a conservative man) in which he tells us that the construction, the grounds and the buildings for the installation, are going to cost eighty million dollars. Compare that with St. Louis—less than fifty million; with Chicago—less than forty million, and you can realize from the comparison what is being done on that 625 acres on the beautiful Bay of San Francisco. dd to that the forty million dollars of reconstruction in that city within the last seven years, and you have got something worth going to see.

Now we trust that you will give this matter consideration during the next year or two and if your combined bodies can come there, possibly you can invite also some of the foreigners interested in your industry and have some conferences. By all means invite the engineers and foundrymen from abroad. You probably know that the engineering societies have organized an International Engineering Congress already, and 800 of the most notable of foreign engineers abroad are coming to that great International Congress. In fact the exposition is going to be notable for the combining of interests such as, in a small way, is illustrated by your three bodies.

Now let me say two or three words as to some of the practical things in connection with this matter. You will find, when the time comes, that you will be able to go to San Francisco from Chicago as cheap, probably, as you could go from New York to Kansas City. The rate is going to be very low. We are not able yet to announce positively what it is, but it is going to be very low and you will have hotel accommodations that are going to be absolutely all right. The director of the exposition has recently announced that the contract with the hotel association has been written up and they have an agreement with them not to advance prices. They have today nearly 3,000 hotels and large apartment boarding houses. They are able to take care of 200,000 people today in San Francisco, Oakland, Berkeley and the neighborhood right there within twenty minutes or half an hour from San Francisco. So that you are going to be well taken care of if you do come. You will have a great exhibit, in addition to your own exhibit, the great exhibit of the exposition. You will be royally welcomed and we trust that we will see you in 1915. I am simply laying the foundation for your consideration, so that you may think the matter over in the meantime. [Applause.]

President Olsen:—The next paper is by Mr. C. E. Knoeppel, of New York City, *How to Make a Time Study.*

Mr. Knoeppel then read his paper which will be found in a previous portion of this volume.

President Olsen:—This paper is now open for discussion or for any questions you may want to ask the author.

There being no discussion, the meeting was adjourned.

Third Session. Wednesday, October 15th, 10 a. m.

President Miles in the chair.

The Chairman:—Before we proceed to the reading and discussion of the papers, I want to announce the appointment of the committee for the nomination of officers for the next year. On that committee I name Major Speer, of Pittsburgh; Mr. R. A. Bull, of St. Louis; Mr. L. L. Anthes, of Toronto; Mr. A. F. Corbin, of New England; Mr. H. O. Lange, of Chicago; Mr. W. H. McFadden, of Oklahoma; and Mr. Thomas D. West, of Cleveland. If there are no other matters to bring up this morning, we will proceed with the reading of the papers. The first subject is *Gray Iron for Motor Car Castings*, by Mr. H. B. Swan, of Detroit, Michigan.

Mr. Swan presented his paper in the shape of running comments. Paper and discussion will be found in other portions of this volume. The address was accompanied by a series of fine lantern slides showing the microstructure of various classes of cast iron.

The Chairman:—I am glad to see so much discussion on this paper. The next subject will be *Electric Steel Castings*, presented by Mr. F. T. Snyder, of Chicago.

Mr. Snyder presented his paper, and a general discussion of the subject of *Electric Castings* followed, embracing therein the Hiorth paper on the same subject. Papers and discussion are in other portions of the volume.

The Chairman:—The next paper to be presented is that of Mr. E. R. Swanson, of Granite City, Ill., on *The Pattern Shop as Related to the Foundry.*

Mr. Swanson presented his paper after some preliminary remarks of special interest to the gray iron casting founder. The paper will be found on page 235 of this volume.

The Chairman:—After the interesting talk on the *Pattern Shop*, we will listen to Mr. R. A. Bull's paper on *Some Difficulties in Pouring Steel Castings.*

This paper was discussed at length, and special action resulted therefrom. The paper is given on page 151, and the discussion in another part of the volume.

On motion of the Secretary, a committee on Steel Foundry Standards was authorized. This committee was appointed at the following meeting.

The Secretary then presented the next paper, in the absence of the author, and made some extended remarks on the subject. The paper was entitled *Some Observations on Miniature or Detachable Open Hearth Furnaces*, by W. M. Carr.

Further, the Secretary also presented the paper on *Electric Furnaces for Steel Castings Purposes*, by Mr. Albert Hiorth, of Christiania, Norway, a paper richly illustrated with lithographs made in Norway for this meeting. The importance of the subject was dwelt upon and the hope expressed that we would see more of the electric furnace for high grade material in this country.

This ended the Steel Castings papers, and the Secretary then presented the Malleable Castings papers, going into the subject at length. The papers by Mr. P. Rodigin, of South Russia, Mr. E. L. Leasman, on the *Study of Annealing Malleable Castings*, and lastly the Secretary's paper on the troubles met with in malleable shops in making serviceable castings, were all taken up.

The advanced time prevented extended discussion. But subsequent to the meeting many questions were asked, and answered by the Secretary, who had gotten into close touch with the two authors first mentioned and knew of their work. The meeting then adjourned.

Buffet Luncheon and Theatre Party.

At the close of the morning's session, those present were the guests of the Chicago Convention Committee, at a buffet luncheon, served in the hall of the meeting. This was thoroughly enjoyed by all, and much time saved thereby. The gentlemen then met the ladies at the theatre, and a pleasant afternoon was spent listening to a bright musical comedy, staged with a profusion of molders' tools and foundry supplies.

FOURTH SESSION. THURSDAY, OCTOBER 16TH, 10 A. M.

President Miles in the chair.

THE CHAIRMAN:—The meeting will please come to order. I announce the following gentlemen as constituting the authorized committee on Steel Foundry Shop Standards: Dudley Shoemaker, Chairman, American Steel Foundries, Indiana Harbor, Ill.; A. H. Jannsen, Bettendorf Company, Bettendorf, Iowa; John H. Ploehn, French & Hecht, Davenport, Iowa; Thos. D. West, Jr., West Steel Casting Company, Cleveland, Ohio; L. A. Way, Duquesne Steel Casting Company, Coraopolis, Pa.; A. H. Thomas, Buckeye Steel Casting Company, Columbus, Ohio; R. A. Bull, Commonwealth Steel Company, Granite City, Ill.

THE SECRETARY:—*Mr. Chairman and Gentlemen:* In my secretary's report I requested the appointment of a committee on papers, and our Executive Board have been talking that over very carefully and also believe that it is important that we have a committee on papers so as to make it easier for this office to get out a good programme for the year. I would therefore move that the President be authorized to appoint a committee on papers.

Motion seconded and carried.

THE SECRETARY:—I would further move that the Committee on Costs be revived. This matter was mentioned by the President and myself in our reports. We originally had a committee and they made an excellent report. It is, however, now necessary to revive it again and to work out a little more thoroughly the question of standard costs for the foundry. I would like to say further that in this Committee on Costs, I would suggest that our president, Mr. Miles, be made the chairman, as he is the most active man available and the man most able to bring it into effective use.

Dr. Moldenke's motion was seconded and adopted.

THE CHAIRMAN:—As a committee on papers I will appoint Joseph J. Wilson, of Detroit, as chairman, and the other members will be L. L. Anthes, of Toronto; H. M. Lane, of Detroit; H. E. Field, of Pittsburgh; Thomas D. West, of Cleveland; A. O. Brackart, of Cleveland; R. A. Bull, of St. Louis; H. B. Swan, of Detroit; and H. A. Carpenter, of Providence, R. I. The Committee on Costs will be appointed later.

MR. WILSON:—I would like to offer this resolution: *Resolved*, That a cordial vote of thanks of this Association be given the Foundry and Machine Exhibition Company for their very generous donation of $500 for educational work given this Association, and that the Secretary so inform that association.

THE SECRETARY:—I wish to second the motion and I would like to add, in that connection, that this $500 was given last year, and that the Exhibition Company was cordially thanked by the President and myself at the time but as the Association votes a special thanks now, this will be gladly forwarded by the Society.

The motion was then adopted.

MR. ESTEP:—Our annual subscription dinner will be at the Congress Hotel, Michigan Avenue and Congress Street, at seven o'clock this evening, and we hope every person will be in attendance. We have made an extra effort to provide a programme which we feel will be unique and of unusual interest, and we trust that you will all be there. It will be absolutely informal.

THE CHAIRMAN:—I hope that all of the members here and their friends will attend that banquet to enjoy what they are to give and to show our appreciation of Chicago's hospitality.

If there is no other matter to bring up, we will proceed with the presentation of papers. The first paper on the programme for the day is entitled *The Need of Standard Specifications for Cast Iron*, by Mr. R. S. MacPherran.

Mr. MacPherran then presented his paper, which was thoroughly discussed. Paper and discussion will be found in other portions of this volume.

THE CHAIRMAN:—Before going on with our discussion I would like to say that we have with us this morning Dean B. Connelley, of the Carnegie Institute of Technology and I would be glad if the Dean would honor us by sitting on the platform, and I will ask Dr. Moldenke to escort him here.

[Dean Connelley was escorted to the platform by Dr. Moldenke and received with applause.]

THE CHAIRMAN:—If there is no further discussion, we will proceed with the next subject, *Memoranda on Automobile Cylinder Founding*, by Robert Crawford.

Mr. Crawford presented his interesting paper, which was so ··adily understood that no further discussion resulted.

THE CHAIRMAN:—There being no discussion, we will pass on to Mr. H. M. Lane's paper on *Core Tests and Specifications*.

Mr. Lane did not read his paper, but gave a very full synopsis of the contents. The paper and discussion will be found in other portions of the volume.

THE CHAIRMAN:—There being no further discussion, we will proceed to the next paper on the programme. Prof. E. A. Johnson, on *Testing Molding Sand under Commercial Conditions*.

In the absence of the author, the Secretary went over the salient points of this interesting development of the original Association Molding Sand Tests, these tests being extended by Prof. Johnson, at the Wentworth Institute, Boston, by practical applications on a commercial foundry scale.

The paper will be published subsequently, as it was received too late for printing previous to the convention.

Mr. Wilson having consented, owing to the lateness of the hour, to have his paper go over to the afternoon, Prof. Clifford B. Connelley, Dean of the School of Applied Sciences, Carnegie Institute of Technology, Pittsburgh, was next given the floor by President Miles, and delivered an interesting address, fully illustrated by lantern slides, on the method of educating young men for foundry work, as pursued in his institution.

Dean Connelley prefaced his address by the following:

PROF. CONNELLEY:—Good Dr. Moldenke wrote me a letter some time ago and wanted to know whether the Carnegie Institute of Technology would add their mite in the form of a paper to help the Foundrymen's Association in its convention at Chicago. Well, to say the least, the Foundrymen's Association of Pittsburgh has helped Pittsburgh so much and helped the Institute so much that we could not say other than "yes, we will do our part;" so I will try now, in the brief time I crave your indulgence, to describe the part that the Carnegie Institute of Technology plays in the development of modern foundry practice.

Prof. Connelley promised to send in a copy of his address for publication in this volume. The discussion will be found elsewhere.

The Secretary then presented the paper of Mr. Frederick A. Parkhurst, on *Put Your House in Order*, and also the one by Mr. E. W. Riker, on *The Need of a Common-Sense Cost System*

for the Foundry. Both papers are highly interesting and instructive. Owing to the lateness of the hour, as well as the completeness of the papers themselves, there were no questions asked on either.

The meeting then adjourned.

Fifth Session. Thursday, October 17th, 2 p. m.

President Miles in the chair.

The Chairman:—The first paper of the afternoon session will be by Mr. J. J. Wilson, of Detroit.

Mr. Wilson then presented his paper on *Vital Points in Foundry Practice.* There was no special discussion of this paper.

The Secretary then presented the paper by Mr. D. C. Wilson, of Newark, N. J., on *Iron, Where Does It All Go To?* and also that of Mr. G. S. Evans, of Lenoir City, Tenn., on *The Relative Value of Foundry Flour, with Simple Methods of Testing.* These papers are published in another part of the volume.

The Chairman:—The next paper on the programme is by Mr. Thomas D. West, of Cleveland, Ohio, entitled *Memoranda on Accident Prevention.*

Mr. West:—*Mr. President and Gentlemen:* About five years ago your speaker was instrumental in starting an Anti-Accident Association at Sharpsburg, Pa. A few months later we attempted to call a convention, endeavored to get people interested in the accident work from different parts of the country to attend this meeting in New York City. At that meeting there were representatives from the Steel Corporation, the Bethlehem Steel Company and several other large concerns of the country. While it was not a large gathering, it was a very representative one. It was really the nucleus or the starting of the anti-accident crusade. A short period after that the speaker brought out a little book on the accident question. The theme running throughout this publication was the "personal factor." The question of safety devices was thoroughly recognized and encouraged in every way possible, but I gave the greatest attention to the personal factor. It became rather discouraging to me in the course of my work along those lines in

which I spent much of my money to further, to find that the "personal factor" was becoming neglected and the "safety device" was tied to. But on second thought I made up my mind not to let it worry me, for we would eventually have to come back to the personal factor after all. This is the point I want to make here this afternoon, gentlemen. We are largely back today to that issue. You see it in your Chicago street cars, "Public Safety Crusade." As you go along the railroads, you find placarded in the switch houses and every place quotations "Safety First." It means the personal factor. As all manufacturers of any experience know, we may do all we can, and everyone of you is doing all he can at the present time, with safety devices, but at the same time we will find that the personal factor is the most serious one. You must educate your men to be watchful, to look out for themselves. We have today some things that are very inconsistent and highly detrimental to the manufacturer. We have our States passing laws inflicting penalties on the manufacturer when men get their fingers lost or an eye put out. You or the liability company will pay all the way from ten up to twenty-five or maybe thirty thousand dollars to settle for that. If it is a life, why that, in our State, is thirty-five hundred dollars. It is put on the basis that when a man has passed away that is the end of him, but if he is left a cripple for life, he is dependent on somebody else who must support him and for that reason you must pay heavily. The point I am getting to here is the inconsistency of this law. They will pass that kind of a law and at the same time let a saloon open next door to your office. Your men can steal out unknown to you or even dig tunnels that you won't know about; they will get out, they are gone for a minute or two, are back in your shop and you haven't missed them. You don't know they are half loaded until you see somebody swaggering around with a little loud talk and then you know what has happened; but maybe they have got hold of a crane or a ladle of iron and there's an accident and they have not only injured themselves but several others. You pay for it, but still the State goes on and allows that saloon to stay next door to you. It seems to me that this question of the saloon ought to be made a national issue, that it ought to be driven away from the manufacturer's door. I do

not know how it may appeal to some of you gentlemen, but to me it grates very hard to see a nice handsome office, a gateman and iron gates, just a few doors below a saloon, and here you've got men with buckets of beer passing right in under your nose, You can go in and see them sitting around the tables. And still many manufacturers will tell you they are controlling their business. I do not want to take up much of your time, but my paper is based on the personal factor. I have come back to the foremen of your shops, asking them to be watchful, guardful. You may have done all you can with the safety device; now I want them to do their part.

Mr. West then read his paper, which will be found in another part of this volume.

THE CHAIRMAN:—This question of safety appliances is receiving a great deal of attention lately. Some of the interest exhibited by legislatures, while commendable, has been misdirected and certain laws have been passed that are not for the best interest of either the employer or the employee, but the intentions are good and legislative action can be so guided that better regulation can be obtained. The National Foundrymen's Association has a Committee on Safety of which Mr. Alexander. who addressed us Tuesday afternoon, is a member, and that committee has employed an expert to help the members and he is at the service of the members for some nominal price to go through their plants and recommend safety and sanitary appliances. We might take some further action and have a committee, if it is deemed advisable, there being a good many members of this Association who are members of the other.

THE SECRETARY:—It might perhaps be a good idea for us to revive our former Committee on Safety, of which Mr. West was the chairman. If you think it advisable, I will make a motion to that effect.

THE CHAIRMAN:—That might work perhaps to the best advantage. It might be the sentiment here that we have a committee of that sort.

MR. WEST:—I will be very glad to do all I can on the subject if the members feel that way.

Dr. Moldenke's motion was seconded and adopted.

THE CHAIRMAN:—Mr. West, I believe, was to be chairman

of that committee and I will suggest that he select the other members of it. The next paper, by Mr. W. S. Quigley, of New York City, is on the *Use of Powdered Coal as Fuel.*

Mr. Quigley then read his paper, and illustrated it with numerous lantern slides. The paper will be found in another part of the volume.

Dr. Moldenke then briefly outlined his paper on the *Centrifugal Blower for the Foundry,* and the floor was given to Mr. W. S. Hoyt, of Chicago, who described the oxy-acetylene welding and cutting process, and illustrated his remarks by copious illustrations with the lantern. The paper as well as the discussion is printed in another part of the volume.

THE CHAIRMAN:—We will now proceed to unfinished business.

THE SECRETARY:—You will all remember Prof. E. Heyn, of Berlin, who was our guest at the Buffalo Convention. I was glad to be able to send him our last year's bound volume, and he in return sends us his hearty greetings and thanks us for the kind reception given him. The letter being in German, most of you would not understand it, hence I give only the substance.

THE CHAIRMAN:—We are very glad to hear from Prof. Heyn and hope he will favor us with his presence again.

Proceeding now to new business, we will receive the report of the Nominating Committee.

REPORT OF THE NOMINATING COMMITTEE.

The chairman of the Nominating Committee reported the following:

For President:	Alfred E. Howell, Nashville, Tenn.
For Vice-Presidents:	R. A. Bull, Granite City, Ill.
	H. A. Carpenter, Providence, R. I.
	S. B. Chadsey, Toronto, Ont.
	G. R. Lombard, Augusta, Ga.
	T. L. Richmond, Buffalo, N. Y.
	T. W. Sheriff, Milwaukee, Wis.
	J. J. Wilson, Detroit, Mich.
	Walter Wood, Philadelphia, Pa.
For Secretary-Treasurer:	Richard Moldenke, Watchung, N. J.

It was moved by Major Speer and carried, that the report of the Nominating Committee be received and filed and that the nominations close. A motion was then adopted that the Secretary of the Association cast the ballot for the gentlemen named by the Nominating Committee. The ballot was cast accordingly and the nominees declared duly elected. The chairman thereupon appointed Mr. Bull to escort the new president, Mr. Howell, to the platform. This was done and Mr. Howell was received with applause.

Mr. Howell:—Gentlemen, I can only say that I am profoundly grateful for this honor. I am so much surprised that I am totally unable to make any remarks to you that could enlighten you in any way. It is a special honor to serve as one in the line of those distinguished presidents whom we have had for eighteen years, and I assure you that everything that can be done by your newly appointed officer will be done and that he hopes for the hearty co-operation of every member of the Association, without which he feels that he could accomplish very little. [Applause.]

Mr. Seaman:—It has been my custom and my privilege to rise and make a motion to have our retiring president elected an honorary member. I now make that motion with the greatest of pleasure as to our retiring president, and hope that you will all agree to nominate him unanimously as an honorary member of our organization. [Applause.]

The motion was seconded and was unanimously adopted by a rising vote. President Howell then took the chair.

Mr. Miles:—Fellow Members, I want to express my thanks at being allowed to join that galaxy of ex-presidents who have done so much for the foundry industry. I want to assure you that the work in the last year has been a pleasure and that I have had the support of the membership. We have had an active and large membership. The present enrollment is 765 members, which is an increase of new members of, I believe, 166 in the last year. The meetings have been interesting and the discussions well carried on. I wish an even greater achievement for my successor. [Applause.]

The Chairman:—Gentlemen, as your new officer in the chair, I suppose there is hardly any real business that could come

before this body at this moment. There is, however, an honor and a privilege that I propose as the first act in this office to exact, and I will request Mr. Seaman to please come forward to the platform. Will the Secretary please conduct Mr. Seaman to the platform?

[This was done and President Howell thereupon delivered the following address.]

ADDRESS OF PRESIDENT HOWELL

In Presenting the Silver Loving-Cup to Past President Joseph S. Seaman.

Mr. Seaman, and Gentlemen: The phenomenon of growth in nature is one that doubtless many, if not all of you, have pondered. The seed is planted; it germinates and by degrees we see the stem, the leaf, the bud, the perfect flower.

It is almost axiomatic in nature that the more highly developed and valuable the product, the longer the time in process. The soft wood grows rapidly, the hickory and the oak are of slow growth. Man of all living beings, the most helpless in the beginning, develops by slow degrees to the highest type of God's creatures.

Thus rapidly suggesting the proof of my corollary I pass on to say that in 1896, in the incipiency of the American Foundrymen's Association, Mr. Seaman planted the flower that has blossomed these eighteen years, and ripened the fruit of perfect love.

It is difficult to tell just how and why certain things happen in this world. Sometimes we do things because we feel impelled by an invisible force. It is not at all a new idea, this of giving to you, Mr. Seaman, some token of our love. This year it seemed to permeate the atmosphere.

We wanted to give visible and tangible and enduring expression to those sentiments for you that fill our hearts.

In attempting to do so, there is room for the widest difference of opinion as to what could, if anything indeed can, adequately represent our feeling. You remember Harry Lauder's song. He is dancing with his girl, and swings her around rather lustily. She shouts, "Jock, you will tear my frock, you will have me black and blue." Says he, "I will buy you twenty frocks, that's

how I am feeling the noo." Well, that's the way a good many felt, just like buying the whole shop. There's our friend McFadden, I think he would have gotten a loving cup as big as this rostrum. But no one has been allowed any special privileges in this matter. It is the many, each look in for only a little, and the selection of this pitcher and waiter was controlled by the thought that we wanted to come to our friend in a close and intimate relation by service, as he has come to us and endeared himself, without ostentation or display.

Wrought by hand with thousands of loving licks of the hammer, these pieces symbolize the thousands of helpful thoughts that have guided us on our way to our present development. This token to you, Mr. Seaman, is not of love as originating with us, but of love as reflected to you. We love you because you first loved us, and we hope you will keep these near you, and use them daily. And when you grasp this handle, let us fondly think that you are grasping us by the hand, let us feel that we are ministering in this simple and homely fashion daily to our good and only true "Daddy."

Mr. Seaman:—Gentlemen, I do not know what to say. Only this, perhaps, and in a few words. It was not necessary for you to give me this cup to show me the love and respect that you all have for me. I knew that and I hope that I will continue to have it for the few years I have still got—I do not know how many they will be. I hope that our Association will continue to be the success it has been in the past. I believe I am the oldest past-president living. There were two before me; they have gone to their account. Some that have been there since I was have gone to their account, and I sometimes consider myself as the next in order; but I want to say one thing, that you have imposed a duty upon me today, and that is a duty I thought of while my friend was talking here. You have caused me to change my will. Now, it is something very strange, that a man on an occasion of this kind should make such a confession, but I shall cherish this gift and I hope that my successor in age will get it, and that it will be continuously passed down to the oldest living past-president for years to come. Anything further than this I cannot say, only to thank you and to let you all know how I appreciate what you have done for me.


DADDY
President
Chicago
ion Chicago 1913 – J. S. Seaman – A token of love from his many friends in the American

I sometimes think there are a couple of boys that call me "Daddy" here who have been pushing things pretty lively, and I would like them to say something and give an account of themselves for what they have done. [Applause.]

The Chairman:—Major Speer, won't you say a few words?

Major Speer:—Mr. President, I cannot say much at this moment For quite a number of years they used to call us "The Three;" they put the "Big" in front of us—Mr. Seaman, Mr. McFadden and myself. As Mr. Seaman began to grow older and Mr. McFadden and I younger, they nicknamed us "Daddy and his boys." In consulting with Mr. Seaman on matters of the Association, his advice was always taken and in a great many cases he got his boys not only out of trouble but out of a good licking. It is my hope and wish that we will attend a great many more conventions together. I wrote to Mr. McFadden asking him whether he would be at this convention, told him that "Daddy" had got it into his head that he was in a condition where he was a little bit too old to travel. Mac said, "Nonsense." I went and consulted with Mr. Seaman. "Well," he said, "If Mac is coming 'way from Oklahoma to attend this convention, I think I am able to travel, and I'm going." In the meantime he had taken a heavy cold, was in the house and in bed. I went to call on him and he was just barely able to get around. He said, "Joe, we are going to the convention." I said, "I don't know that you'll be in condition." He said, "I will go if I have to crawl, I will be there because Mac will be there." And the only thing that I can say, gentlemen, is that I will try and be good, and I will guarantee that Mr. McFadden will do the same thing. [Applause.]

Mr. McFadden:—I don't think, members of the American Foundrymen's Association, that I can add anything to what has already been said. The eloquent presentation made by our newly elected president was very fitting in words and very expressive. Mr. Seaman's response touched me very deeply, to the extent that I realize and we all appreciate the fact that he is growing old, but that does not signify that he will not be with us many more years to come and attend many more conventions. Major Speer, in dwelling upon the subject, sort of takes the burden upon himself to the degree of placing Mr. Seaman in

that aged condition, and I want to relieve Major Speer of that burden by saying that it is my youth that keeps those two young and able to attend conventions. [Laughter and applause.] It is commonly known and recognized that, to stay young, is to keep young society. The result of that is that, up until this convention, I have always heard it said it was "the son and the two fathers." Classed that way because it kept the two fathers busy to keep the son out of devilment. So, now that there are two sons, I've got a brother, but I didn't know it until this convention. I recognized them before and honored them both as fathers, but I don't know whether I will humble myself to the position that I have aged to the extent that I will allow the Major to class himself as my brother. I will take exception to his remarks to that extent; outside of that I want to say that every convention I have attended, I have attended with the desire and expectation of meeting, along with the other members of the American Foundrymen's Association, Mr. Seaman and Major Speer. That has been one of the inspiring features to look forward to in an annual convention. I can say this, as this is a moment when compliments are being paid by us to each other, that I too occupied the same position Mr. Seaman did when Major Speer asked him about coming to this convention. I, unfortunately, was taken into a hospital last Saturday, and there went through a serious operation, but I telegraphed that I would be in Chicago if Major Speer and Mr. Seaman would be there, if I had to crawl. I am looking forward to next year and being at the next convention, whether it is held in San Francisco or any of the eastern sea port or the inland towns; we three expect to be at that convention.

Major Speer then offered the following resolution, which was seconded by Mr. McFadden and adopted:

Resolved, That the members of the American Foundrymen's Association in annual convention here assembled do hereby express to the Chicago Convention committees, the local and trade press in attendance, the Foundry and Machine Exhibition Company and the management of the Hotel LaSalle, and other hotels of this city, their hearty thanks and expression of appreciation for what they have severally done to make this convention a success, and the stay of its members a pleasure while they have been in Chicago.

Be it further Resolved, That the Association extend its further thanks and hearty appreciation to the Allied Associations which have gathered here, and to our Secretary and past officers for their co-operation and,

Be it further Resolved, That this Convention hereby votes its approval of the proceedings and actions taken by our Executive Committee during the past year and pledge a similar support to the newly elected executives.

THE CHAIRMAN:—I think, in addition to the passing of these resolutions, as our members meet and come in contact with the gentlemen who served on those committees, it would be a good thing to tell them how magnificently they have conducted their part of the programme and thank them in person, as I shall tryto do myself, and not leave it simply to the formal matter of reading it in print. Is there any other business?

THE SECRETARY:—I would like to move that the special thanks of the Association be given to those who contributed papers to this convention and otherwise helped us with that work.

THE CHAIRMAN:—That is a very pertinent resolution indeed. [The motion was seconded and adopted.]

THE CHAIRMAN:—Is there any other business?

THE SECRETARY:—That is all there is on the programme with the exception of the invitations for the next convention. If in order, I will present a few things in that line.

THE CHAIRMAN:—With your permission we will have the Secretary read the invitations that have been received by him for the next convention.

THE SECRETARY:—I will only give the name of the cities, with the exception of one letter which is addressed to the Foundrymen's Association and reads as follows:

STATE OF TENNESSEE,

EXECUTIVE CHAMBER

NASHVILLE, TENN., Sept. 10, '13.

To the American Foundrymen's Association,
Chicago, Ill.

GENTLEMEN:—Wherever the name of Tennessee has gone there too has gone her reputation for hospitality. It is, therefore, in accordance with history and tradition for me, as Governor

of this State, to invite you to hold your next convention in one of our cities. Here you will find yourself on historic ground, replete with more than usual interest; a country beautiful by nature, whose attractions have been enhanced by the hands of man.

Your hosts will be keenly alive to the honor you will be doing them by holding your next convention in their State, and will do all in their power to contribute to your pleasure while you sojourn among them.

Very truly yours,
BEN W. HOOPER,
Governor.

THE SECRETARY:—The individual cities inviting us are Nashville, Tenn., and Chattanooga, Tenn. In addition, we have strong invitations from New York City, Philadelphia, Denver, Kansas City, St. Paul, Atlantic City, Galveston and Columbus, Ohio. Under the constitution, the matter, of course, goes over to the Executive Board.

THE CHAIRMAN:—Is there any other business, Mr. Secretary?

THE SECRETARY:—No, sir.

THE CHAIRMAN:—If there is no other business, before we adjourn I would like to ask those members of the Executive Committee present to meet in the south end of this hall for a few minutes on adjournment because this will probably be the most convenient time for us to get together.

There being no further business, on motion of Mr. Seaman, the convention then adjourned.

THURSDAY EVENING, OCTOBER 17TH.

SUBSCRIPTION BANQUET.

The evening was given over to a magnificent subscription banquet at Congress Hotel. Besides a fine menu, there was entertainment by vaudeville, and no speech-making of any kind.

The banquet concluded the festivities of the Convention. The ladies, in the meantime, had been lavishly entertained, and every one went home feeling that it had been the most successful convention ever held, and the high point in the Association history.

DISCUSSION ON MR. R. A. BULL'S PAPER ON "SOME DIFFICULTIES IN POURING STEEL CASTINGS."

The Chairman.—We would be glad to have Mr. Ploehn, of Davenport, Ia., discuss this paper, as I understand he had something prepared on the subject.

Mr. Ploehn.—Mr. Bull has asked me to help a little with the discussion of his paper, and hence I would say the following:

We were working a little on nozzle and ladle troubles this summer, and ran across a few interesting facts that may be of interest to you. The nozzle situation is in a very deplorable condition. Every one has his own designs, and these vary probably by an eighth or a quarter of an inch from the designs of some one else. There being only one used in a heat, in the ordinary steel foundry, even with a large plant, the number of nozzles used in a year is comparatively small in comparison with brick. The consequence is that such small orders as a thousand or two, which ought to be important, are not given the attention in making and in burning that they should have. The work that they do and the importance of the brick, such as it is, is manifest, because the whole heat depends on the nozzle. They are not placed in the kiln properly, a good many times and to the best advantage; they are rushed in and pulled out again; it is a small order put in with everything else, and there are some of them that are not properly burned either around at the sides or at the roof or way down at the bottom of the kiln. It seems to me that it would be a mighty good plan for a number of the foundries or this Association to get together and simplify the designs. In a trip that I made to try to find out how these articles were made, and why they were as rotten as they sometimes are, I ran across probably a dozen designs that varied only by an eighth or a quarter of an inch in some minor dimension from the brick that we were using. The difference would not amount to anything, and yet every man sticks to his own design. Now if these could be boiled down so that the fire-brick people could make them up in lots of

eight or ten thousand, they could then afford to throw away the bad ones and still have enough left to satisfy five or six customers at a time. Now they are in as bad a position as we are. They get small orders and would like to see something done along the suggested lines. Not that each manufacturer would have a special design, but let the foundrymen get together first and simplify their designs and then let each one have his made where he ordinarily gets them from. Then if one man or another is stuck, as happens occasionally, and gets some of them wet, or by some accident may run into a bad bunch, he can get his design or a design so close to his from another manufacturer. In that way you would keep up competition, and improve the product as between the same identical design from two or three different manufacturers, which you cannot get now.

The shape of nozzles is another thing, of course dependent on practice, but that could be boiled down. They are all kinds of angles for the top, round and conical surfaces, but it seems to me there is only one shape for a certain size hole and for a certain class of work that is right. All the existing shapes cannot be right.

It is the same way with the stopper heads. The problem of simplifying the nozzle design and also the stopper head is one that I think the steel foundrymen should get together on, and do something for their benefit as well as for the nozzle maker, which they would indirectly get the benefit of.

While I was on the trip trying to locate some of this trouble. I found out that all kinds of mixtures were made by the firebrick people. Some people wanted this and some people wanted that, and I found out that in certain locations, like in Pennsylvania, there were certain peculiarities of clays, such as a clay with a large carbon content. If the brick was burned too fast, it would trap this carbon and give the nozzle or brick a soft center. As soon as the outer skin was worn off or melted or heated, this soft center would simply melt away and you have no nozzle, simply one large hole. Then in Ohio there were other conditions found in regard to the grinding materials coarse or fine. This is probably getting away from Mr. Bull's paper a little bit, but the nozzle causes, I think, practically seventy-five per cent of the trouble. Very little trouble is caused by the graphite head,

but the nozzle is the point to watch in steel pouring, especially where the metal is hot. On steel foundry work where you have a large number of molds to pour, requiring perhaps from three-quarters to an hour or an hour and a quarter, it is of very great importance.

Another little wrinkle gotten up to help us in this trouble—we had some of it this last year—was the shape of the bottom. A bottom is ordinarily rammed up of different compositions, whatever they may be; graphite, loam, fire clay, or sand, depending on the shop, and this would be rammed up by hand and there were no two ladles that you might say had identically the same slope. Next to the nozzle, it is important to get at somewhat near a perfect slope and condition for the "bottom." We got up a sweep which fits in the nozzle. A pin that fits in the nozzle, or a false nozzle, set in its proper position and the upright fitting into a false goose neck where the ordinary goose neck would not fit, and then having a steel plate swung loosely on this axis and sweep that around as far as we could from side to side, forming the bottom next to the nozzle absolutely identical and the same on all ladles. The shape would have to be determined by the shop condition, the kind of ladle and the kind of work. There is one certain shop, however, that works a great deal better than some others. For instance large work requires a flat bottom and a little sharper bottom could be used for small work and give quick pouring and hot metal, and it helped us out a great deal in keeping the bottom from having puddle holes in it or little low spots. A man's eye suffers, especially when down in the ladle, with artificial light and in the summer time, the ladle probably being hot, from using four or five hours before. The eye fools him and he wants to get out there as soon as he can. The consequence is that the man puts a bottom in as quick as he can.

Another little kink that we use is in making up stopper rods. We found out that when they were lying flat on a bench, we had more or less trouble sometimes with the joint opening up. To prevent this, the sleeves were all slipped on the rod and the head put on while it was lying horizontally and the mud or clay was put in between the sleeves, quite enough of it to get a good joint. Then the rod was hung by its bolts or nuts at the top on to a pin that just cleared the floor; then the sleeves were ground to a fit

with the mud or clay between, while hanging in a horizontal position with the weight of the sleeves up above tending to help this grinding. So you would have a perfect joint under the conditions in which you are going to use your stopper, and you would have enough weight on top for the grinding action to be able to really do some work, so that all your sleeves would fit perfectly and you would have the minimum amount of fire clay between the joints.

Another thing, when made in the horizontal position, the rod having play in the sleeve, this will always fall or lie next to the rod and have more clay on one side than the other, and the sleeve will not be concentric with the rod, whereas, by hanging them, they will be concentric and will get uniform pressure and a mighty fine stopper rod. This, of course, prevents any leakage in the joints, which happens occasionally.

There are no further points that I care to bring out at this moment, but the ones given are just a few of the things that we bumped into this last year. After we got them straightened and tested out, they worked out to pretty good advantage, and overcame about seventy-five per cent of our troubles. The other twenty-five were caused by the nozzles not being burned properly or bad. I cannot emphasize too strongly, that the steel foundrymen or the Foundrymen's Association ought to get together and do something on this nozzle proposition. The manufacturing and handling of the large number of designs make for a very poor nozzle, and there is nothing in it for the manufacturers of nozzles, and certainly nothing in it for the steel foundrymen to use such nozzles or run chances unless the foundryman wants to get two or three years' supply ahead of him, and then run chances of having some of them spoiled when they get too old or collect too much moisture, or his work changes so that he has a large number on hand that he cannot use for the class of work he is then doing.

Mr. Bull.—About how many designs of nozzles did you find?

Mr. Ploehn.—Well, on ingot practice I found that the designs were far fewer in number than on steel foundry practice. Ingot practice requires a large hole, comparatively small nozzle, not very high, not very large in diameter and usually set at an angle of about forty-five degrees, and that practice seems to be far more standard. I saw probably half a dozen designs that were used

for different sized holes that were used by probably eight or ten steel mills for ingot pouring. For steel foundry practice, however, I found that holes all the way from an inch to two and a half inches and as high as fourteen designs for the same size hole were used, and some of them did not vary more than an eighth or a quarter of an inch in diameter at the bottom or some little variation at the top. For instance, the slant at the hole in one case would be an inch, and in another case, an inch and an eighth and in a third case, an inch and a quarter. Then they would have some round face and some were what you might call concave. But it seemed that the majority of designs had a straight face, at an angle of possibly thirty degrees for steel foundry practice. The variation was small, but still some of these designs were ordered in large lots, and some others only in small lots. This is another reason why I think the Association or the foundrymen should get together—it's the small man usually who suffers with his small lot orders. He is strictly up against it, because it takes six weeks to two months to get new nozzles after he gets his last order. If he finds out they are no good—it takes about six weeks or two months to get a new batch of the same design. The nozzles ought to be thoroughly dried before they are put in the kiln, which is different with small lots. They make them up one day and rush them in, and the consequence is that the burning is very short, making a hard surface and soft interior.

I am rather interested because I went to so much trouble and spent so much time last spring and summer to go into the subject, and I fully appreciate what the conditions are. Some of you people have been pretty lucky, perhaps; so were we until this year, but when trouble comes, it comes in bunches.

I would like to hear from some of the steel foundrymen, as to what they really think of this matter. Some of you people perhaps have ideas along other lines.

Mr. West.—I would like to offer a few remarks in regard to stopper troubles. We handle converter steel and there is not much hotter steel made, and when you get a running stopper with hot converter steel, it is the hardest thing to stop. We went into the solution of the nozzle problem and found a certain form that we thought was better for our practice. We only ordered small quantities, as is natural, because you cannot put in a car-

load of material, and we thought we were away from our troubles. We were ordering a six-months' supply. At the end of the six months the company had forgotten all about our design, had lost it, and shipped us a lot of foreign nozzles altogether different from the kind we were using, and we found they were troublesome and we could not get any results. This was the third or fourth shipment we had received from the same makers, showing three or four different kinds of nozzles. We have very little trouble with graphite stoppers. We also tried to taper the hole. A common practice is to use a striker and strike the stuff back. We found that in converter practice we had the hole in the nozzle. We reverse, and take a pair of pincers and pull the plug out, taper the opposite way, and got rid of our troubles in that way. I think the suggestion that a committee be formed to get a specification for a standard nozzle, is a good one.

Mr. Ploehn.—I would like to ask whether your practice or your design would not suit other people that are using converters?

Mr. West.—Well, we have run between five and six years in converter practice and started from the first on the bottom pour, which, at the time, was considered almost impossible on account of the high temperature of the steel. We were told by the open-hearth people and others who had had some experience with hot steel, that we could not pour converter steel and pour it hot out of the ladle. At the time the practice seemed to be to pour it from the lip, but we know that we get our clearest and best steel right from the bottom of the ladle at all times, and the standard that we are using I don't think is anything uncommon or unusual. We would be willing to submit this to the committee or send some samples down to them and they could look them over and see if it is different from any others.

Mr. Bull.—How long did you say you had been pouring?

Mr. West.—Between five and six years; and we will have between two and three hundred openings out of a three-ton ladle and we pour all of our steel from the bottom.

Mr. Bull.—That would be pretty good evidence that leaks were not occasioned by steel being too hot in the open-hearth practice.

Mr. West.—No, we have found that when you get a ladle

with hot steel you cannot close it up readily, but with medium steel you can close it up if you work the stopper properly.

Mr. Norfolk.—I would like to ask Mr. Ploehn whether he has had any experience in regard to the nozzles taking up moisture in six or nine months? I ask this for a purpose. We formerly found that our predecessors at the plant had bought a thousand nozzles at a time and were paying $90 per thousand. We sent out and asked for quotations and got them for $30. If they were standardized, I feel that we could even reduce this, so whether it is a question of poor buying by our predecessors or the amount we are buying will reduce the price that much, we do not know. We have had no bad experience from keeping the stoppers on hand.

The Secretary.—Another question has been asked. Whether, in your tour, you found special attention given to reducing the force of the stream coming from the ladle to the mold in the design of the nozzle?

Mr. Ploehn.—Around an open-hearth plant or possibly a converter plant, you all know with fire brick, silica brick, magnesite, or any of those bricks, you ought to keep them high and dry and at a uniform temperature as nearly as you can. It will not do to let them get out in the cold in the winter or to leave them out in the sun in the summer. You could perhaps, after you had the design settled, carry a carload or any large quantity of nozzles on hand, but if you consider that you have got to carry probably a hundred other shapes of bricks for your furnaces and ladles, it makes it a pretty big problem. When you get into the thing, it really requires a special building that is absolutely weatherproof and possibly heated slightly to keep the stock right, because around open-hearth steel, there is nothing of greater importance than the quality of your refractory and to have it in proper condition. I am glad you mentioned the matter about the price. Just as you stated, the price of nozzle brick is all the way from $30 to $100 a thousand. I found some prices due to the various designs requiring molds out of iron, and also due to the fact that they are ordered in such small quantities. They set up a machine to make them, it may run an hour or two hours and the order is out. By simplifying the designs and having several people get together to use any one design, you could get the nozzles for

half the price. By making a day or several days' run of one design, you could get the price considerably reduced and the manufacturer could then afford to throw away the bad nozzles and culls and not be out anything; but you run an order for a thousand and if they find a hundred or so bad, it is rather against business judgment to throw them away as long as they are not using many and you get a lot of bad ones that you are paying for. It is such a small item that you usually let the thing go.

With reference to Dr. Moldenke's question about pouring, we seem to find that the users of nozzles who require a larger number of pours on open-hearth steel find that the flatter the seat (that is, the angle of the slope of the seat), the nearer it is to thirty degrees, the better it seems to pour and last. The sharper it is, forty-five degrees, or even more, the more likely there will be a wedging action between the nozzle and the stopper head. In some cases foundrymen have put rings around the nozzles to keep them from spreading out at the top. Of course that can be prevented by a proper design, but you get a better seat by having a flatter surface than you do by having a sharper one, and you partly reduce the cutting action. It does not get the velocity on a dull or flat incline that it does on a sharp one.

DISCUSSION ON MR. H. M. LANE'S PAPER ON CORE TESTS AND SPECIFICATIONS.

The Chairman.—This is a very interesting subject and one that should bear fruit when the investigation is completed, although some good can come of it now. The question of what material to use in cores and the time of drying are very important questions to which I do not think many foundries give the consideration that they should. The matter of getting rid of your moisture in cores and putting them in at the right time so as to have a core that is not burned but a core with the moisture out of it, is a very important matter. Mr. Lane brings out the point that, as long as your moisture was there, the material would not be affected. I have had a good deal of experience in making tests on various materials in vacuum and it is interesting to note that delicate materials which cannot stand much heat can be dried in a vacuum if you stop at the right time. Under a vacuum, as you know, the atmospheric pressure is relieved and the boiling point of the water, with a practical apparatus, runs down around a hundred degrees Fahrenheit. You can take a delicate material and pick it up on a rotating drum in a vacuum, dry off the moisture and, as it comes around on the other side, scrape it off with a knife. The moisture content may be three to seven per cent and you get very fine material that you can put in ice water and dissolve. For instance, take coffee and boil out the essence and concentrate it, dry it on a drum in a vacuum and put it in ice water and it will dissolve. Or put it in hot water and of course it will dissolve quickly. You get everything except that fine flavor; though in fact, it is a good deal better than the coffee you get at some cheap hotels. There are a great many materials, among them the fruit products used to drink, that are dried in this way and can be dissolved very readily; where, if they are dried in the open air, under a high heat, they are either spoiled or at least you would have to take boiling hot water to dissolve them, and they sometimes have a burnt taste. While this does

not apply to our subject, it shows how materials can be handled without injury if you stop at the right time, and it is important that your core ovens be arranged and controlled so that you can get your high heat to start with to facilitate speed in drying and cut down the temperature as your core gets drier, so as not to injure the binding material, particularly on the outside. I will be glad to hear further discussion on that subject.

Mr. Wilson.—What has been said brings to my mind one thing about drying cores, especially oil sand cores, and that is this: When is a core dried sufficiently to give the best results? We put a core in the oven and bake it, perhaps at not a very high temperature or it has not remained there very long, and it comes out the natural color of the sand, although perfectly hard and sound. The color is the natural sand color, except that the smoke may have discolored it on the outside, which would make it look as though it were baked brown, but by scraping it off, you find this is the natural color of the sand. Now, if a core is in that condition, as compared with a core that is baked until it is a light chocolate color, though at a point where it has not been baked sufficiently so that the edges begin to crumble; then it is good. Now, in our work especially, and anyone who is in the automobile end of the game knows, core blows are numerous, the core that is just dried so that we have the natural color of the sand may give a core blow, where the core which is dried or baked until it is a light chocolate, will not blow. Now, by testing this out, for instance, on a plate which is hot enough to crumble the core up, you will find that from the core which is well dried, there is scarcely any smoke or gas arising, but the one that is not, there is quite a large volume of smoke and gas. Now, that smoke and gas does not always come out through the vent; the volume is so great that the minute your iron runs over it is bubbling through. The gas must rise or get out somewhere, and the volume is so great that it will come up through the thin layer of iron. The least boil or bubble in a casting of that kind produces what we might call a spongy spot. It would be a spot that would leak. These spots will come where the suction is perhaps a little heavier, so we say that the design is wholly defective on account of the extra heavy suction, where possibly part of it is simply foundry or core-room practice in not drying the core sufficiently. Only

when the oil in the core is dried or baked so that it is in a crispy form, yet not sufficiently so that it is rotten, is when we get the best results with oil-sand cores in this kind of work.

The Chairman.—Are there any others who can give us their experience on this subject? In drying cores there are sufficient difficulties encountered from the fact that you dry different sections of cores in the same oven, and that is a subject which ought to be carefully considered by foundrymen in their work, because many a casting is spoiled by having a core that is overheated and burned and crumbles and crushes when the mold is poured; or under dried and the moisture escapes and causes trouble such as Mr. Wilson speaks of.

Mr. Lane.—I would like to say something further. Mr. Wilson's point is well taken. With automobile work it is necessary, with certain types of oils, to carry them to such a point that you have driven out all of the turpentine and all bodies that are volatile at that temperature, to get down to the residual binding oil, and you have got to do that with certain types of cores. Sometimes you can select a different binder, a different type of oil which will give its maximum strength and still not give sufficient volatile constituent to produce the boil. If you can, that is the core you want to use. When you bake to the chocolate color, usually you lose about a third of the possible binding power of the material. Your core will be about two-thirds as strong as it would be at the maximum point. If you pick out a different binder which gives the proper binding power at its maximum point and still does not give a boil, you can often make a decided saving. You may have in some foundries two types of cores, say for exhaust pipes and cylinders. In the exhaust pipe, you have got a bigger core, you can use a binder and stop it at its maximum strength, while you have got to carry the other on down to drive out these volatile constituents in the oil-sand cores. This applies also to flour and dextrine cores. One of the most interesting cores along that line I ever saw was made to make some very, very thin steel castings, so thin that it seemed almost an impossibility to make them. They were also very large, and the core was made of Welsh mountain clay, old sand, new sand and sawdust. There was no other bond, as we commonly know it, in the core, and it was baked at 550 degrees until the sawdust

was pretty thoroughly charred. It was so charred that if you shook it it would go on the floor like a heap of ashes. You had to set them with gloves, but once in a mold they released all right. Here was a case where we had driven out all the volatile constituents and it only released because it contained so much sawdust as charcoal. There was an extreme case of driving out all the volatile constituents and getting the weakest core you possibly could.

DISCUSSION ON MR. W. S. HOYT'S PAPER ON OXY-ACETYLENE WELDING AND CUTTING.

The Chairman.—Are there any questions on this subject? We thank Mr. Hoyt heartily for the interesting presentation. I have seen some castings illustrated here that I did not suppose could be welded with success, principally those cylinders made of cast iron.

Mr. Wilson.—I would like to ask what dangers there are attending the operation of a plant of that kind, if there are any?

Mr. Plumly (speaking for Mr. Hoyt).—I would say that the danger is equivalent to that in operating any gas plant. If it is operated in the right way there is practically no danger, but if it is carelessly handled there is considerable danger. There is danger about any gas plant.

The Secretary.—I would like to ask one question, What is the character of the metal after the weld is made?

Mr. Plumly.—The metal is soft. In a very hard casting, there is used a filler with about three per cent of silicon. For steel castings Norway iron is used. In any event you get a material which it is probably difficult to explain, but has a chemical composition which is not deleterious.

The Secretary.—Do you oxidize the metal at all in welding up?

Mr. Plumly.—By adjusting the valves of the blow pipe, you can make either an oxidizing or a neutral flame; it is simply a matter for the operator.

The Chairman.—Can very large castings be welded unless you set a piece onto the end of them? For instance, I had an eight-foot diameter elbow at one time which had a piece out due to a brick coming up through it and I engaged an acetylene welding plant and an expert to weld that piece. He thought he could do it but failed. I found that on heavy castings I can do more with a burn by pouring hot metal on it than by using an acetylene weld.

Mr. Plumly.—That depends largely on the individual job, but with proper free heating and skilful operators, a man can weld almost anything, even in cast iron. He can start at the bottom and continue to build his metal up to the top of the crack. That was done yesterday at the convention hall with the cast iron base of an air-compressor, and the crack was so located that it was necessary to weld almost overhead, but the operator was skilful and did the job satisfactorily.

DISCUSSION OF MR. F. T. SNYDER'S PAPER ON ELECTRICAL STEEL CASTINGS.

A Member.—I would like to ask the speaker at what cost of electricity can you compete with coal, say at $2.00 a ton?

Mr. Snyder.—Well, the competition does not come as simple as that; there are other elements involved. It is not a question of electric heat against fuel heat, but of electrically melted metal against fuel melted metal. Frequently the electric melting can use cheaper scrap than the fuel melting. In general the furnaces running on jobbing casting work are using electricity that costs on an average one and a quarter cents per kilowatt hour; in some cases a cent and three quarters, and in exceptional cases it runs down to about one cent. There is one other point I might say we run across occasionally, and that is whether electrically melted steel can be made too hot. Anybody who thinks about it will realize that there is no practical limit to the temperature you can get. We find that the foundrymen frequently make their steel too hot; they make it so hot that they have to hold it in ladles or get castings that do not anneal properly. Then of course the colder you can pour the metal, the better it is from a blow-hole point of view, whether made electrically or any other way.

A Member.—I would like to ask if you have any figures on the converting cost, just considering the cost of converting the metal into the open ladle?

Mr. Snyder.—These figures refer entirely to simple arc type furnaces. There are some figures given in the paper here which run from $27 down to $20, working twelve hours. If the furnace works twelve hours and the foundry ten hours, or from $23 down to $18, running from five tons a day to twenty tons a day, on a twenty-four hour basis. These are figures that run a little under the ordinary side-blower converter cost, under the same tonnage conditions.

Mr. Devereaux.—What is the comparative furnace loss of the electric furnace and side-blower converter?

Mr. Snyder.—Well, there are furnaces running in which the foundryman who owns them claims no metal loss. It depends on how you operate. If you operate an electric furnace on a reducing basis you can make a basic or acid slag, which means that the iron content in the slag is very low indeed. On the other hand, the side-blower converter loss will run anywhere from possibly twenty per cent down to eighteen per cent.

The Secretary.—Did you ever get a minimum of ten per cent?

Mr. Snyder.—Well, it depends on how it is done, but I want to give a low figure.

The Secretary.—I think the minimum will be found to be pretty nearly around seventeen per cent, meaning thereby cupola melting and converter losses.

Mr. Snyder.—I was talking about the actual loss in the converter.

The Secretary.—When you begin to figure the capital end of it, the actual money expended and the actual results obtained, you have to add considerable. I see a great many estimates that, on the face of them, look quite nice, until you begin to figure on the actual money to be invested and actual result you can hope to get, and then things look differently.

A Member.—Is it conclusively proven that electric steel is superior to steel melted by other methods?

Mr. Snyder.—I think you can put it a little differently and say it can be made better. As it is now, you cannot get any more money for electric castings, or very little more, and the result is that it does not pay to make electric castings any better, but it is well known that if you want to put the furnace time on it you can reduce the sulphur and phosphorus very materially and the steel comes up in quality. Then it does seem to be a fact, why we don't know, that the electrically melted metal makes a casting which is stiffer. This shows up in the foundry in getting heads and gates off, they don't come off near as easily as they would even off of the crucible metal of the same composition.

A Member.—The possibilities are there, but the makers have not used the possibilities in the furnace.

Mr. Snyder.—They get better castings, but do not get any more money for them.

Mr. Smith (of Toledo).—Is the cost table intended to represent the same capacity of furnace running at a low temperature?

Mr. Snyder.—No, those are furnaces run to capacity under similar conditions.

Mr. Smith.—Have you figured that out on the basis of kilowatt hours?

Mr. Snyder.—In getting that table up it was, of course, taken from a regular rating sheet.

Mr. West.—Do you have any special electric furnace that will do things better than any other on the market?

Mr. Snyder.—I happen to be interested in electric furnace manufacture, so this is not the place to go into that, but in this small type of work it is pretty well settled now that an arc furnace, with a single arc, is a type which has worked out best in small foundry work, purely as a matter of convenience, and the tendency seems to be in that direction in the United States.

Mr. Smith.—Single arc furnace—is that a single pole furnace?

Mr. Snyder.—Yes, sir, single arc electric furnace, either D. C. or A. C. current. The initial electric steel melting furnace was developed by Mr. Siemen, the same man who gave us our open-hearth furnace, about thirty years ago, and consisted of a circular shell with a vertical electrode sticking down into the top of it, and at that time, thirty years ago, it was the simplest type and it is one of the very simplest types coming into general use in this country today; the single pole in the center, having one electrode.

The Secretary.—How about the induction furnace?

Mr. Snyder.—There is one induction furnace running on job casting work in this country, but I have not been able to learn anything about the results they have obtained.

Mr. West.—What do you consider a fair temperature on your steel for pouring?

Mr. Snyder.—That depends largely on the carbon.

Mr. West.—Take casting steel, twenty or twenty-five carbon.

Mr. Snyder.—I have been trying to get at that quite a while. In a rough way, the steel runs around 1400° C.

Mr. West.—After you have melted your steel, what proportion of electric heat does it take to get the heat to the temperature it acquires in an open hearth furnace? If you run your

temperature up, are you running into the danger of melting down your roof?

Mr. Snyder.—In any furnace the danger is the roof material and that does not differ seriously between an electric and an open-hearth furnace. There is some difference though; that is, in the electric furnace the heat is down on the slag and in the open-hearth furnace the gas is pretty well up under the crown, so that, for the same grade of refractories, the electric furnace will run its steel to 100 to 200 degrees C. hotter than the open-hearth furnace will with the same roof material.

Mr. Chandler (of Pittsburgh).—How many heats is it possible to take out of the furnace in twelve hours? Or does that depend on the size of the furnace?

Mr. Snyder.—It depends on the size of the furnace, but what the foundryman wants is, to build furnaces that run a heat every two hours, and that is independent of whether they run twelve or twenty-four hours.

Mr. Chandler.—Are there a great many preparations that have to be made before you start the second heat, placing the electrodes or anything of that kind?

Mr. Snyder.—No, the electrode doesn't take any time. It is a question of charging the furnace, the same as it is in the open-hearth practice. If there's a hole in the bottom it has to be patched.

Mr. Chandler.—There are things you have to do, so you could not make a general run every two hours.

Mr. Snyder.—Well, I have got hundreds of charts showing the time that the current was on and off, representing thousands of heats, and they average very close to twenty minutes. Some of them run down as low as fifteen and some up as high as half an hour, but these are all very small furnaces, less than five tons, so they are charged readily and the average time is pretty close to twenty minutes.

The Secretary.—There is one fine thing about the electric furnace, that when you have your temperature up to the point you want it, this temperature can be kept high in order to have the steel clear itself of the slag. It is ahead of the other processes in this one respect.

Mr. Snyder.—Of course you can get very hot metal in the con-

verter and that can be held. It is not uncommon for the converter metal to pour one ladle full and hold that ladle while you are getting another heat; that gives a good chance for the slag to come up, but there is very little slag in an electric furnace.

The Secretary.—I notice that in the steel rail problem the solution seemed to lie right at this point, that if you could hold the steel twenty minutes and keep it hot enough to pour, you could get a steel rail which would not break.

Mr. Snyder.—It is just a question of expense; it costs a certain amount to keep up the radiation for an electric furnace, and if the market is available for the quality of results, you can let your steel stay there and let these various slag materials come to the top, and you have a steel which is very free from foreign material in the sense of being chemically combined. I have here a few samples taken from the ordinary run of electric steel in foundry work, not castings but heads and gates and one or two fins, showing how hot steel has been poured. One of the fins I have is interesting in that it represents the pouring of forty flasks out of a hundred-pound ladle that took so long that the other ladles had to come back and be filled three or four times each in the meanwhile. The castings are very small, they weigh only a few ounces each.

DISCUSSION OF MR. H. B. SWAN'S PAPER ON GRAY IRON FOR MOTOR CAR CASTINGS.

The Chairman.—Does the degree of heat used in making pig iron affect its structure as well as the rate of cooling? In making charcoal pig iron, the best metal is frequently made with the use of a cold blast.

Mr. Swan.—Yes, sir; much depends upon whether the blast is cold, warm or hot. Further, undoubtedly the rate of cooling has a great deal to do with the structure of the iron. I have here several plates showing the difference in the size of the crystals between the sand cast and the machine cast pig irons.

The Chairman.—Have you any in which the same ores have been used, some in the charcoal furnace, and others in the coke furnace, so that the differences may be readily seen?

Mr. Swan.—I regret very much that I could not get this information, as I know of no two furnaces using the same ore that way.

(Mr. Swan then gave a series of running comments on slides thrown on the screen—as described in his paper. The descriptions elicited much interest and the following discussion then took place.)

Mr. Cowan.—I notice that one of the first irons mentioned was a charcoal iron. I would like to ask if better results have been obtained by using charcoal iron in connection with the other irons for automobile parts, particularly cylinders?

Mr. Swan.—For our part we have found that the charcoal iron is very much better for the reason that with charcoal iron in your mixture you can run with a lower content of silicon than you can with coke irons only. For some unknown reason, charcoal iron seems to work better. It does not pay to use it for all castings, but for those parts which require more ductility and strength than others, it is a very good plan to use it. I know of one case wherein we were running a very large engine base. It was a very intricate casting, very light, and we had some trouble

with the castings cracking. The composition seemed to be all right, not so high in phosphorus as to be brittle, but probably the trouble came from the strains set up in the iron as it cooled around hard sand cores. The iron was not ductile enough to allow these strains to adjust themselves. We found that by using charcoal iron we got away from this trouble.

The Secretary.—I would like to corroborate what Mr. Swan has said in that connection, because we know that in malleable practice, if an attempt to use a coke iron in making malleable castings with less than .75 silicon is made, there will result all kinds of trouble. On the other hand, charcoal iron with as low as .10 silicon gives perfectly successful results. In the production of charcoal pig iron, the furnace is run so much finer, the action is so much more exact, that the oxidation prevalent in the other irons is not so marked. The strains would be there anyhow whether charcoal or coke irons were used, but charcoal iron stands the strains readily and coke iron does not.

The Chairman.—What explanation have you to make in connection with iron that a machinist calls "gritty," that may have, on analysis, composition that should give a good casting, but still it will be gritty in that it will act like sand on the tool and dull it?

The Secretary.—This is hard to say. I feel certain that a good deal of our iron is not clean enough when it is cast. Slag is made in melting, there is lots of dirt in the material charged, and if the temperatures are not high enough so that the metal in the ladle can clear itself, the impurities are apt to go into the castings. I have noticed that ferro-silicon in melting would run out into the ladle and finally into the casting. I have found lumps of ferro-silicon right in the castings. Then there is another thing, the manganese and sulphur will get together in the ladle and not have time to come to the top, under the slag, as a manganese sulphide. It is a matter that is being worked on these last few years, to try to reduce the sulphur in the iron before it is cast. Our scrap is gradually rising in sulphur year by year. When I first went into the foundry business, gray iron scrap used to average about .06 sulphur, and today if you can get it better than .12 you are doing pretty good. There is the constant melting and re-melting, and the sulphur from the coke gets into the

iron. Hence the sulphur is steadily rising. If the iron can be gotten extremely hot in the melting, whether in a furnace, open hearth or cupola, and then be allowed to stand twenty or thirty minutes absolutely quiet, the reaction going on between the sulphur and the manganese will result in a manganese sulphide and it will have time to rise slowly to the surface, getting between the slag and iron. If you can draw from the bottom of the ladle, you are practically cutting the sulphur from .08 to .04 to .05 and probably the gritty material mentioned is this very manganese sulphide.

The Chairman.—In a case called to my attention, a large bed plate was analyzed and contained about two per cent in silicon, which was higher than need be for that type of casting, yet it was made from a combination of pig iron and scrap. The other elements were normal. The iron turned out what we call very gritty and the tool would not stand up on it at all. It did not look dirty. It was too large a casting to have grit in it all the way through, but there were present light particles that powdered more or less instead of cutting off in nice ribbons.

The Secretary.—The chances are that the very illustrations we saw here today have a bearing on this question. You will have noticed the large streaks of graphite that ran through some of the castings, and I imagine a tool coming along and cutting through the iron part and hitting the little streak of graphite is lubricated while it goes on further till it strikes the next streak. A casting like that will plane off like cheese. But suppose these graphite streaks are not there, you have not the lubrication of the tool, and the chances are that you find considerable hardness and possibly also the surrounding material will allow the lifting out of some little grains as the tool goes along. High sulphur will form bands of sulphide of iron around good iron, and when you cut through with a tool, you lift some of the crystals right out.

Mr. Wilson.—About eleven years ago, shortly after I went with the Lane & Faulkner Manufacturing Company—what is now the Cadillac—and at that time we had no chemical work done, there was a general complaint in the machine shop that the iron was hard. I found on looking into it, that it was not hard but it would wear the tool off. It seemed to be gritty. I had several of the samples analyzed and found that the silicon

was about 3.20 per cent. So I attributed that wearing off of the tool to the excessively high silicon. We all know that in drilling high silicon pig for an analysis it is pretty hard on the drills. It will wear them off rapidly. When I reduced the silicon to between 2.75 and 2.50 we had no more trouble.

The Chairman.—In the case I mentioned the silicon was not high. I understand that one of the automobile companies uses pig iron with 3.25 silicon. I do not know what the rest of their mixture is, but they get a very soft iron, and make everything in sand: piston rings, cylinders, fly wheels, etc.

Mr. Wilson.—I think you will find, Mr. Miles, that some of them are using a very soft iron for cylinders and are using a high percentage of steel. By using the high percentage of steel in light castings of that kind, it is necessary to have it very soft; I should say perhaps in a mixture there might be 2.50 to 3.00 silicon, and it is possible to get a casting free from segregation in that way that you cannot get otherwise. Mr. Swan has done considerable work in this line during the experiments that he has been running, with mixtures running high in steel and very soft on certain castings which had never been known to come absolutely sound, owing to their design, but with a high percentage of steel and running very soft they would come absolutely sound. We are not yet prepared to say that this is the best iron to use, therefore we are not using it, but we are carrying on experiments as to the wearing qualities in the laboratory and hope perhaps by next year to be able to say something about the matter authoritatively.

The Chairman.—We have made some castings and got very good results with a mixture similar to that you speak of, a high percentage of steel with a high silicon iron. It seems to give the desired results.

Mr. Abell.—They use almost exclusively a No. 1 northern strong iron and work in nearly forty per cent scrap, about fifteen per cent of which is steel, and the balance is cast iron scrap, but the pig iron part of the mixture is almost entirely a No. 1 strong iron running about 2.75 silicon.

Mr. Bauer.—I just happen to know that the Ford Motor Company as well as the Cadillac are very large users of charcoal iron. Incidental to the remarks of Mr. Abell, I just want to say

a word about charcoal iron. It seems to me that in the great number of years since chemistry has been taken up we have been educated to look to silicon almost entirely to solve nearly all the problems in connection with gray iron foundries. The correspondence schools and various others are laying more stress on the silicon than any other one element. I came into the foundry business about the same time that chemistry came into the gray iron foundry; I think Dr. Moldenke will recall that, and in the past two years my experience has rather led me away somewhat from silicon. There are so many other things taken together that go to make up the physical quality of the casting along with its microscopic condition, that silicon really seems to play a small part. Along the line of the discussion of this casting question the President refers to, I had an experience not long ago where a foundryman was having considerable trouble. His castings were running 2.00 to 2.25 silicon, and he was having many breakages. I advised him to get away from silicon. I said, "drop it down to 1.25 but get a warm blast charcoal iron made very slowly in a furnace, as this practically prevents an iron oxide content in the iron." I have known from experience, in charcoal iron especially, that it seems to be a more homogeneous iron because the furnace is not rushed to get the greatest number of tons, and the character of the fuel tends to make it very soft and homogeneous. It takes a great deal of nerve to try to run a mixture with the silicon down to 1.25 per cent, but I am sure that it is being done every day. I believe the day is coming, if we keep on improving the quality of the pig iron, when you can make the iron almost without silicon.

The Secretary.—Out of some eight thousand foundries, I think seven thousand nine hundred do not melt iron perfectly and they have to use silicon to overcome the difficulties that come from imperfect melting conditions. They unfortunately keep on adding silicon until they get to the point where they add too much, before they realize that prevention is better than cure. I remember the time when 2.25 to 2.50 was a common thing for silicon; today we use 1.75 and even 1.25 for silicon and can do so with perfect success because we have got to know how to melt iron right. If you have bad melting, charcoal iron will help you through, but if you have coke iron, it will not. If we watch

our practice carefully we can get along with a great deal less of silicon. It is the condition of the carbon we must look after and this is affected in the greatest measure by silicon. Therefore this has been given the greatest share of attention.

Mr. Bauer.—Do you not think that the microscope in time is going to lead us to a point where we know the state of carbon in iron, as we do not seem to know it today? I do not want to be taken too seriously about that silicon remark I made, but we all know that we are not going to get rid of it, it will always be with us, but I really think the microscope is the great unknown field, especially for the gray iron foundry. The steel people have used it and it opens up a great field that the laboratory cannot reach without it.

The Secretary.—When the importance of silicon first came to be realized one man called on me and asked, "Who is this Mr. Silicon?" [Laughter.]

Mr. Butler.—It seems to me that this discussion of the question of hardness in gray iron castings is very fruitful of investigation. I have seen castings contain as high as three per cent of silicon, which produced the same effect you speak of in dulling the tools. While my friend Mr. Bauer is on the right track in regard to the percentage of silicon, it seems to me that the whole thing resolves itself back, to a great extent, to the temperature at which the iron solidifies. We know that the temperature has a great effect upon the production of the different carbides, silicides and phosphides of iron that we find in our castings, and, as Secretary Moldenke has said, we must not only look after the chemical composition, but we must follow the temperatures at which our castings are poured at and the temperature at which they solidify.

INTRODUCTION TO AND DISCUSSION OF DEAN CONNELLEY'S ADDRESS ON THE CARNEGIE INSTITUTE OF TECHNOLOGY'S SCHOOLS OF APPLIED SCIENCE.

Dean Connelley.—We are extremely proud of the work we are doing and trust that every man who comes through Pittsburgh will take occasion to stop and see us. I am sorry that Mr. Lane does not live in Pittsburgh, because he said his experiments with cores and core sands cost money and he could only go on with his experiments if he had it. Well, we have it, and if he would come to Pittsburgh we would lend him a little bit of Mr. Carnegie's money to carry the experiments on. I have worked in a foundry and I know what it is to have the cores just right. We are making tests right along; my paper will show you just what the Pittsburgh Foundrymen's Association is doing for us. At a Congress in New York last week, we talked over what we were doing and showed what could be done by the different institutions, both engineering and industrial schools of this country, and we believe, starting out as we have and other institutions starting out, that there will be very few accidents in the foundry, machine and other shops eventually. If you do not get the kind of a man you want with the opportunities you have today in these great industrial schools, it is partly your fault. You know as well as I do, that competition is so keen that everybody must be up on their toes doing things, but when you consider the papers given here this morning, it just acts as an impetus to make the people in industrial work do their very best.

The Carnegie Institute, gentlemen, stands ready to do anything in its power to help out any institution, the foundry, or any branch of industry. The foundry is just one of them. I sincerely hope that if there is any intricate subject that the Foundrymen's Association would like to study and they think that we are able to do it, both in the way of gray matter and capacity, that you

will give it to Dr. Moldenke and he will give it to us, and I can assure you that we will do our very best. Now, if you will just turn out the lights, I will show you what we are trying to do, very hurriedly. I am sorry that we have no more time, but it could not be helped.

[Dean Connelley then exhibited the lantern slides, giving an explanation of each as presented. The full text of his formal address will be found in another part of this volume.]

The Chairman.—I am sure, gentlemen, you have all enjoyed as much as I have, the very interesting talk of the good dean from the Institute at Pittsburgh. Mr. Carnegie has not made a more generous and useful gift than the gift of this institution to Pittsburgh and the country; and the purpose of the Institute is the training not only of men for positions requiring high technical knowledge, but to give practical men a better knowledge than they can get in the actual daily work of the shop. It is something that works for the improvement of industry, and cuts out, as applied to our trade, by this education, that notion in the foundry business that certain things do happen and nobody knows why. Those who have had this training and a broader education know that there is a cause for all troubles and for all failures, and it is this kind of an education that helps the practical work of the world. I want to extend the thanks of this Association to Dean Connelley for his valuable paper and for his talk to us. [Applause.] If there are any here who would like to ask Dean Connolley any questions in connection with the technical work of the Carnegie Institute, I will be glad to have them put.

Mr. Crawford.—There is only one question I would like to ask: Supposing a boy goes to Pittsburgh from Detroit; what preparations are made to board him and take care of him there? Suppose he was going to take a course of study in the School, is there any boarding house attached at a nominal cost, and what is the cost?

Mr. Connelley.—The cost of putting him through would depend largely on the boy. As he would be from out of town, it would cost him $30 for his tuition. He could get through, for his first year's work, for about $50; then it would depend largely on the boy. We do not have boarding houses or dormitories yet, we are too new, but we are making strides toward that end. A

boy can get through there for about $25 a month; that will include his board, his laundry, etc. We have now an employment bureau, and last year the boys in our school made $125,000 in salaries. We had 2,700 students there last year, and you can imagine what that would mean, even though they worked at a nominal figure, but nearly everybody who goes to the school works at something. Now we have an Employment Bureau, in which Mr. Bole, of the Westinghouse Machine Co., helps us out a great deal, and it naturally depends largely on the boy himself. The cost of living in Pittsburgh is just as much as the cost of living in any other part of the country; I am speaking now of New York City and Chicago; but we have what is known as a "Commons." We have that open every day except Sunday, but there are many of these young men who will club together in this boarding house and get through on $20 to $25 per month.

The Chairman.—You take boys and teach them at night and they can work in the day time?

Dean Connelley.—Yes, sir, the major portion of our students are night students; we have graduate engineers and we have men in some of the departments there who have just got beyond fractions in school. It depends altogether on what school they desire to enter. If the graduate engineer comes into our school, he evidently wants something in his business that he has not been able to get while he was an engineer, and we give it to him. We give him this in the Schools of Applied Industry.

There is no examination required; there is no test, only a personal interview and the good intent. The good intent is worth much to us. You know there are two classes of boys that come to schools such as we have, one is sent to school, and the other comes to school. Well, the "come to school" fellow is the one you can always depend upon, and the "sent to school" boy is the one we simply have to watch. It is a school that is very cosmopolitan; we have no rules, we do not want any; we have a student organization—a student senate—that takes care of things. One man is as good as another when he comes into this school, and the only way we can determine that he is not good is by his shirking, and the whole make-up of the Institution is to make him a better citizen. When we get the Carnegie stamp on his back, if he is a foundryman, in the foundry business, you foundry people will

want him, and our only product is the "boy." We have about seven engineering courses; we have ten building courses, and have courses in machinery.

We also have a School of Design, for the interior decorators, the fine painters, the architects, the illustrators—and this is something new—we have a School of Dramatic Art. We have a theater that will seat four hundred people.

This is varying a little bit from the foundry business, but I would just like to explain, now that I have begun, that this School of Dramatic Art is not a school for actors; it is a school for the engineer, if you please, to put into operation the most pleasing thing that the public would want; for instance, the engineer would do the lighting, the architect the work of constructing, look after the acoustic side of it, etc. Then would come the artist to do the painting and the dramatic art man to do what he pleases there. This is something entirely new, but it is the technique of this work that we teach, the same as we do in music.

I consider that of all the schools we have the greatest is the Women's School that is named after Mr. Carnegie's mother. In this school—all of you know better than I do perhaps the struggle a girl of today has had and how she will try to get an education—in this school we give it to her. She comes in there ill prepared for an education, first just the night school, just as in the Industries, and we take care of her and coach her along until she gets hold of herself.

The great difficulty we find with women and with men is that they are not honest with themselves, they will say they know a thing when they do not know it. It takes us perhaps three or four months to get under their shell, to try and tell them that they are the same as we are and ought to know what they think they know, because they are only fooling themselves.

One of the best things that was ever impressed on us as teachers was in what our Director Hammerschlag says, "I want to tell you that you must get the 'why' when you do a thing, the 'wherefore,' etc.; it does not make any difference whether it is in the machine shop or the foundry or the sewing room or anywhere else, when a thing is done, we want to know why." Just as your President said a few minutes ago here, in the foundry business there was never a mistake made that you could not

scientifically get a basis for. I worked in the foundry business and know. In the early days we did not know, we took it for granted that nobody knew, but there is a reason or it would not happen. We have got beyond that point now. In our schools in Pittsburgh we are just the ordinary people that the other people are in the country, even though we are spending Mr. Carnegie's money, and we do want you to come to see us. [Applause.]

DISCUSSION ON MR. MACPHERRAN'S PAPERS ON THE NEED OF STANDARD SPECIFICATIONS FOR CAST IRON.

The Chairman.—We will be glad to have this interesting paper discussed. Test bars are something to be talked about, and I would be glad if the members would give us their experience.

Mr. Crawford.—I would like to ask Mr. MacPherran whether he puts more stress on a tensile bar or a transverse bar, or if he thinks both should be named together?

Mr. MacPherran.—It has always been our custom to call for both. I think if I had my choice, I would rather have a tensile than a transverse bar, because the tensile bars are almost always machined and that takes away the surface effect, but I think the making of these bars is so easy that any specification might as well call for both as for one.

The Secretary.—That is a little bit contrary to the trend of things. Mr. MacPherran is so used to fine work in the machine shop and so able to do it, that he naturally feels that way, but ordinarily the tendency is toward the transverse bar only and to cut the tensile bar because it is a very expensive thing for the ordinary foundry to fix up, and the chances of a test are very uncertain. The Germans have absolutely cut out the tensile bar from their specifications and we in our specifications leave it optional, with the expense on the man who wants it. I believe the rather higher figures obtained in the tensile test convey more information than those of the transverse bar, but the uncertainties of the test are such, and the cost is so high, that for universal use the transverse bar is the one that will probably remain. I have not seen two bars out of ten that were fitted with the proper grip for a screw thread; the others had the ordinary V, and the moment there is a slip on one side, a transverse strain is set up and the bar breaks at five or ten thousand pounds per square inch lower than it should have.

A Member.—That does not work against the advisability of having a tensile bar but rather against the construction of the machine to make the tests.

Dr. Moldenke.—Exactly, but in this country you will find about ninety-nine out of one hundred testing machines that are not in proper condition for the tensile test. On the other side they calibrate the machines often and they have their governments test them. The transverse bar is so easy to make that for the purpose of commerce it is the best. For scientific investigation, however, the tensile bar is preferable.

Mr. Kreuzpointner.—I have made thousands of tensile tests and transverse tests of gray iron as well as wheel iron. For about fifteen years it was customary in the Pennsylvania Railroad Testing Laboratory to make fifteen and twenty tests daily for the wheel foundry, as well as a similar number for the gray iron foundry, and the reason why a tensile test is not as advisable and as reliable as a transverse test, is because of the peculiar properties which we find in all metals. All metals are ductile and all metals are elastic. To the degree that the elasticity and the strength of the metal varies, to that degree a tensile strength is reliable. In cast iron it happens that the elasticity and the strength of the metal almost coincide. Now, in making a pulling test, if the machine does not pull so accurately centrally as to give time for the flow of the metal, that is for the ductility of the metal to exert itself before it breaks, then that irregularity of the machine, however small it is, will show itself in the result. And because of the almost impossibility to devise an ordinary commercial testing machine which pulls so centrally, and because of the every-day commercial necessity of making these tests and the commercial necessity of making them under commercial conditions, a tensile test of cast iron is not as reliable as a transverse test. In a transverse test, on account of the distance of the supports, what little ductility and elasticity cast iron has, this has a chance to assert itself. I have found this over and over again. When I got as much as seven tenths of an inch of ductility or bending in a bar of cast iron in the transverse test, I got absolutely no reliable report in a tensile test, because in the tensile test the test piece is shorter, and because of the lack of central pull the bar will break transversely before the ductility

and elasticity has had a chance to exert itself on the quality of the iron. That is one risk, and while I do not depreciate a tensile test if it is made carefully, it is never as reliable as a transverse test.

The Secretary.—I am very glad, Mr. President, that this was brought out, because it seems to follow the general line of the commercial development of the country in cast iron; just the same, a tensile test is a good one if made right.

Mr. MacPherran.—My experience is the same as that of the last speaker in regard to the tensile test being very hard to get right. We had to cut our machine over to get reliable results. The ordinary V-shaped machine will not pull straight and you have to put a ball and socket joint on a machine to get any results at all. But that is the difficulty with testing a bar for tensile strength; if you have a good machine, you get a good test, otherwise not.

Mr. Kreuzpointner.—At the laboratory in Charlottenburg, Germany, they always allow one and a half to two per cent of error in the machine, as accurately as they work and as accurately as their machines are calibrated and kept in good condition.

Mr. Fuller.—The paper brought out one point which, it struck me, might be well to enlarge upon, and that is the idea that semi-steel has, to some extent, become a misnomer. What brings that to mind is the case I came in touch with just a few days ago, where a railroad specified "semi-steel" for quite a good sized contract, steam fittings, largely valve bodies, wanting 27,000 lb. per sq. in. tensile strength. The party who brought this to my attention stated that he had tried earnestly to place this among a number of foundries and finally turned down the contract because he could not get the foundries to agree. While he had had former contracts filled under these specifications, this time he ran up against difficulties and consequently turned down the contract. Now, "semi-steel," as we know, has become pretty much of a misnomer, and while it has been quite successful and consequently buyers have, to quite a large extent lately, been specifying it, had they simply specified the strength which they required in those valve bodies, the contract could be filled without trouble. The point that I wish to bring out is that perhaps if we went back to the old days of good charcoal iron, and not

use large percentages of steel, the valves would be just as satisfactory and the contracts could be filled more easily than if we had to specify "semi-steel."

The Secretary.—I wish to ask Mr. Fuller one question: Can you tell me if the so-called semi-steel of today is not practically a plain fraud on the customer?

Mr. Fuller.—Well, Doctor, I would hardly like to call it that.

The Secretary.—Do not you think it is called by this name to get an extra price for castings not because you are putting steel in the mixtures and giving them only a higher grade cast iron, but to borrow value from the word "steel"?

Mr. Fuller.—There is no doubt that "semi-steel," properly melted, will add strength to the cast iron, and while it is largely, as you say, a fraud, a misnomer, you do strengthen up your cast iron by adding a certain amount of steel and melting it properly.

The Secretary.—Still, in the result, you have only a cast iron even if it is one of high grade for strength.

Mr. Fuller.—Yes, it is largely, I must say, in my opinion, a fraud.

The Secretary.—The point is that the material has not the slightest resemblance to steel, it has not any of the properties of steel; it is a high grade cast iron and only as such is it worth more money, but it is recognized as a deliberate fraud to sell it as anything to do with steel as a product and I think that this Association should not go on record as approving such a thing as the name "semi-steel." Twenty years ago it was a new idea gotten up by Old Father Seaman, and he certainly was entitled to getting an extra price for his castings because they were better than any made before that time, but today every Tom, Dick and Harry melts seome steel in his cupola and most of it does not have a particle of effect because it is not properly melted, and yet a higher price is asked from an ignorant customer.

Mr. Fuller.—I think that if our friend had gone to the foundries and said, "I want cast iron valves that will stand 20,000 pounds," he would get them and they would be as good or better than the so-called "semi-steel."

Mr. Wilson.—We are using regularly a certain amount of steel, and I can bear out what the doctor said, because we have

had analyses made repeatedly of the mixtures with the steel and without in which the steel mixture had the highest total carbon; which indicates that it is nothing but cast iron when you get through with it, although there seems to be an increased strength. Why, I do not know.

Mr. Crawford.—There is one word I wish to say in regard to buying castings; the business of the average purchasing agent today is to beat the foundryman down, and too many times the foundryman falls for this, and to get the price for his work says, "I will make it of semi-steel," which everybody who is familiar with metallurgy knows is just what you call it, a fraud. Instead he should stand pat and say, "My price is three or four cents for these castings. I will give you what you want, and I will stand back of it." It is far better to take that stand than say, "I will give you a superior quality, I will give you semi-steel," when he is not doing it at all, but is only after getting a proper price for good, high grade cast iron.

The Chairman.—I think, in the matter of "semi-steel," when people know how to make it—and it is a fact that some people make semi-steel castings and do not get very good results—when they know how to make it, I think it is a fact that they get a much stronger casting, and they have to take the commercial advantages, as the doctor says, to get a better price, when some other people might make an equally good casting and not call it semi-steel. However, the name semi-steel is a commercial name and in general use and it is used by buyers and sellers. I agree that semi-steel, so called, has not any of the qualities of steel, it is simply a high grade cast iron.

THE USE OF PULVERIZED COAL AS FUEL.

By W. S. Quigley, New York City.

Fuel is one of the most important factors in the cost of production, but until recently the importance or necessity of looking about for a method of using coal more economically than is possible with producer gas installations, was given a fresh impetus by the sudden rise in the price of fuel oil during the summer of 1912.

The recognition of new uses and the increased demand for the conservation of all fuel energy suddenly emphasized the necessity of economy. The supply of natural gas is decreasing, the demand for it for domestic use at better prices practically prohibits its use for industrial purposes.

Only heavy and inferior crude oils are available as fuel and improved methods of distillation render the supply of residual or fuel oil uncertain.

So acute has the strife become to economize that the Carnegie Steel Company have placed "waste-heat" boilers between the reversing valves and stacks on some of their new 80-ton open-hearth furnaces in order to recover some of the otherwise waste heat, and this, be it remembered, in the cheapest coal market in the world.

In addition to all these reasons, legislation prohibiting the smoke nuisance is becoming more general and the old plea or excuse that smoke cannot be done away with no longer exists, as powdered coal properly prepared and burned entirely eliminates it.

In a recent article published by the Department of Industrial Research of the University of Pittsburgh, it is stated that "At the present time Pittsburgh burns in the neighborhood of 15,000,000 tons of coal annually, the cost of which is about $19,000,000. It has been estimated, on the basis of efficiency tests, that there is a waste of $4,000,000 annually which could be saved by proper furnace operation."

In addition to this waste of fuel is the damage caused by smoke and soot, such as extra washing, wear and tear on clothes and linen, house and building cleaning, lighting, etc., which is estimated by Mr. Bird, chief smoke inspector of Chicago, where the smoke nuisance is much less than in Pittsburgh, to be $8 per capita, or $17,600,000 per annum, and this in addition to the direct loss of fuel energy. In reality powdered coal means conservation of our coal supply.

Powdered coal as a fuel is not new, the advantages of this method of firing having been fully recognized in the early fifties.

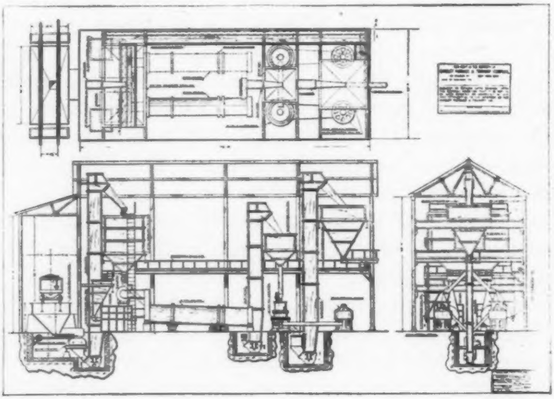


FIG 1.—TYPICAL LAYOUT, GIVING IDEA OF EQUIPMENT USED FOR PREPARING THE COAL FOR BURNING.

It was, however, not a simple matter to burn powdered coal successfully as the enormous sums expended and lost in experimenting have proven. The credit as the originator of the first really successful system of burning powdered coal in metallurgical furnaces, both large and small, belongs to John V. Culliney, superintendent of the American Iron and Steel Company, who persevered and gradually worked out the underlying principles, and perfected a fuel controlling device which turned failure into success. This is proven by the fact that from a small beginning nearly ten years today, he alone is operating over seventy-seven furnaces in one of two plants operated by his company with chambers

ranging from 24 x 30 in. up to 7 x 16 ft. for puddling, busheling, reheating, rod heating, upsetting, etc., burning over 150 tons of powdered coal per day.

My own company has installed plants capable of handling over 240 tons per day and are now installing plants capable of milling, distributing and burning over 740 tons per day in metallurgical furnaces for the following uses: Puddling, busheling, reheating, continuous billet heating, pipe welding, open hearth,

FIG. 2.—MILLING PLANT, SHOWING BINS, DRYER AND PULVERIZER.

case hardening and annealing, plate heating, drop forging, miscellaneous smithing, etc.

I believe that my company was the first building furnaces to see the handwriting on the wall, and to meet the fuel situation broadly with powdered coal. The interest shown and the plants installed have since confirmed our judgment.

The fuel question resolves itself into: What does a fuel cost, what is its heat value, and how much of its heating value can be made effective?

As the cost of fuels vary according to locality and quantities used, and as the work to be done must be taken into

consideration, good judgment must be used. No one fuel is a "cure-all," but, generally speaking, where the fuel consumption will warrant the installation of a coal handling, milling, distributing and burning equipment, the savings which can be made are almost incredible.

For best results powdered coal must be dry and fine. "Dry" means not over one-half of one per cent of moisture (and I might here state that in addition to the advantages in burning, considerably less power is required to properly pulverize dry coal); and "fine" means that 93 to 95 per cent should pass a 100-mesh

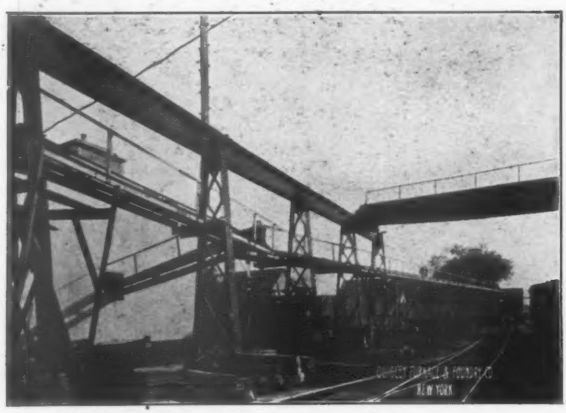


FIG. 3.—CONVEYOR LINE EMERGING FROM MILLING PLANT, BRANCHING TO RIGHT AND LEFT SUPPLYING COAL TO VARIOUS SHOPS.

sieve or 80 to 85 per cent a 200-mesh sieve. In that state the particles are so finely divided that each one, in a proper burning apparatus, is surrounded by the necessary amount of air for combustion and thereby the entire fuel energy of the coal can be liberated at once. It is obvious that the finer the coal the faster it burns, a much greater surface being exposed to the action of the air than when lump coal is burned on a grate.

With finely powdered the volatile gases ignite the instant the fuel enters the combustion chamber and the fixed carbon is consumed while in suspension, the prevalent temperature being very

high. The resultant flame to a casual observer resembles one from either oil or gas and can be varied by the operator by adding more or less air or fuel as desired, at will, by simply opening or closing valves governing the supply. The fire is under absolute control, not dependent upon stack draft or atmospheric conditions, and the entire inflammable portion of the coal is converted into heat without any loss whatever. One hundred per cent efficiency, or each furnace its own producer.

Before giving figures, I will explain roughly what constitutes a plant for properly preparing and burning powdered coal. A coal milling building should be located at a place convenient

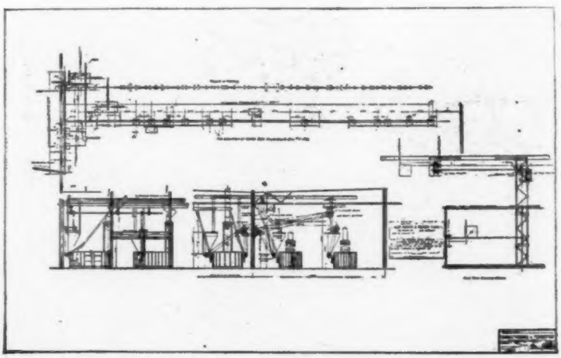


FIG. 4.—SHOWING ARRANGEMENT WHERE BELT-DRIVEN CONTROLLERS ARE USED INSTEAD OF MOTOR DRIVES.

to the supply, from which the coal can be delivered to a crusher and reduced to the size required for pulverizing. From the crusher it must be elevated to a crushed coal storage bin, from storage to dryer, elevated from dryer to dried coal bin, from dried coal bin to pulverizer, elevated to pulverized coal bin, and thence to the distributing conveyors which supply the individual hoppers located near the furnaces from which the coal must be fed to the burners steadily under absolute control. From this you will see why a comprehensive system, complete in every detail, not liable to get out of order, each furnace provided with an ample supply of fuel for a complete turn or day's run, a system on

which you can depend 365 or 366 days a year, as the case may be, is an absolute necessity.

The controller or device which regulates the coal fed to the burners is to the powdered coal furnace what the carbureter is to the gasoline engine; it must be flexible, as it determines the amount of coal which can be delivered or supplied to the burner. The controller shown in the illustration is fastened to the bottom of a specially designed hopper or bin and consists of two screws, the upper propelling the coal forward to a point where it falls in a steady stream past the opening through which it is forced to the burner by a jet of low pressure air, the excess coal

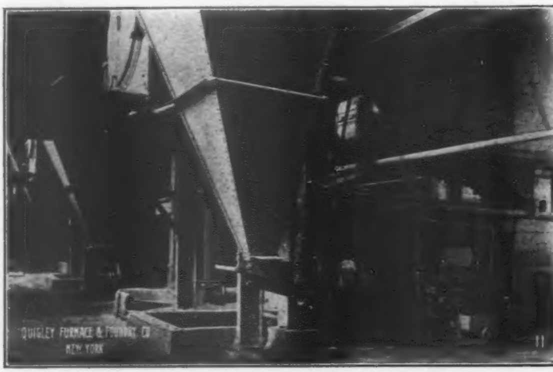


FIG. 5.—SHOWING POWDERED COAL BIN, CONTROLLER AND BURNER ATTACHED TO DOUBLE PUDDLE FURNACE.

falling to the lower screw of greater pitch, which returns the overflow back to the base of the hopper. This construction makes it impossible to jam, is practically fool-proof and permits any portion of the falling stream, up to capacity of the upper screw, to be used at the will of the operator by simply turning on more or less of the air—called "controller air," this being less than one-seventh of the air required for combustion. A separate supply of air for combustion of a much lower pressure is introduced at the burner. The controller screws are operated by either chain drive or are directly connected to variable or constant speed motors, as conditions may require.

On small furnaces, when a more or less uniform class of work is done, such as rod heating, small forgings, nut and spike furnaces, etc., the controllers are speeded up to give the maximum amount of fuel required to heat the furnaces and the operator can not exceed that amount. On larger furnaces, such as open hearth, continuous billet, reheating, etc., a variable speed motor or speed changing device is used to give a wide range of operation. Furnace operators soon become accustomed to the new fuel and have no difficulty in regulating the furnaces to suit their requirements.

The current of "controller air" serves a double purpose. It not only forces the coal to the burner, but in picking up the

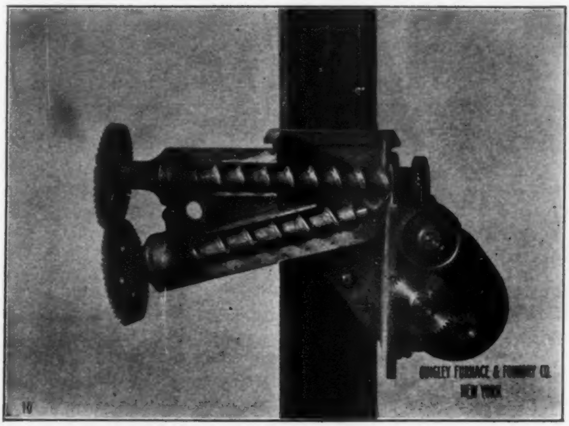


FIG. 6.—POWDERED COAL CONTROLLER—THE DEVICE WHICH FEEDS THE COAL UNIFORMLY TO THE BURNERS. THE UPPER SCREW CARRIES THE COAL FORWARD, ANY QUANTITY OF WHICH IS BLOWN TO THE BURNER. EXCESS COAL IS RETURNED TO BASE OF THE BIN BY LOWER SCREW.

coal it is mixed with it, so that upon entering the burner it expands into a well divided cloud, mixes readily with the combustion air and bursts into a clean flame, the length of which can be changed by adjusting the burner and varying the proportions of the furnaces to suit conditions. The volatile content of the coal also has a material effect upon the length and nature of the flame.

The fires are usually started by placing oily waste, or wood, in front of the burner much the same as starting oil or gas fires, although on small furnaces where oil systems are already installed it is very convenient to use oil for heating the furnace ten or fifteen minutes before the coal is turned on.

In a three-door forge furnace having a chamber about 6 ft. wide by 18 ft. long, used for heating engine frames, etc., in the hammer shop of the American Locomotive Company, the fuel consumption hand fired with bituminous coal was 650 lbs. per hour. With powdered coal it consumes but 350 lbs. per hour and heats 20 per cent faster. This amount will be reduced as the heaters become more familiar with the new fuel and realize

FIG. 7.—POWDERED COAL FUEL APPLIED TO THREE-DOOR FURNACE, REDUCING FUEL CONSUMPTION 40 PER CENT WITHOUT DECREASING EFFICIENCY OF WASTE HEAT BOILERS.

that the smoky flame they were accustomed to so many years is not necessary. In addition, the special grade of blacksmith coal formerly used costs about 35 cents more per ton than the coal now burned.

A report from the Lima Locomotive Works shows that a large furnace for supplying a 6,000-lb. hammer, having a chamber 7 ft. 2 in. x 15 ft. 3 in. started cold at 8.15 A. M., reached a temperature of 2,200° F. at 9.15, and 2,500° F. at 9.45 A.M., which compares favorably with oil or gas practice. The coal used is bituminous run of mine and with 34.70 per cent volatile,

and a heating value of 14,000 B.T.U. per lb., and costs $2.25 delivered at Lima. Allowing 50 cents per ton for cost of pulverizing and distributing, which is a fair average, they get 31,360,000 B.T.U. for $2.75, or 114,036 B.T.U. for one cent, as against 27,282 B.T.U. for one cent with oil, the present cost being $4\frac{7}{8}$ cents per gallon and no possibility of making a contract at that price.

Allowing 80 per cent efficiency and 50 cents per ton for the cost of gasifying a ton of coal (both of which figures are in the gas-producer's favor), average practice considered, the com-

FIG. 8.—FORGE FURNACE—HEATING HEAVY WORK FOR STEAM HAMMER.

parison between oil, producer gas and powdered coal based on the cost of fuel in Lima, O., would be:

Fuel oil	27,282	B.T.U. for one cent
Producer gas	91,228	" " " "
Powdered coal	114,036	" " " "

In addition to the above low cost, about six months per year slack coal can be purchased in Lima 25 cents to 35 cents less per ton than the above figures.

The usual fuel consumption throughout the country is one lb. of pig iron puddled per lb. of coal, although considerably more is used in some plants. One visited a few days ago reports their consumption at $1\frac{3}{16}$ tons of coal per ton of iron.

At the plant of the American Iron and Steel Company, powdered coal records as low as 1,083 lbs. per ton have been made, while a fair average fuel consumption would be 1,185 lbs. of coal per gross ton of muck bar made. The waste heat is utilized in "off-heat" boilers mounted over the furnaces, and to preheat the air for combustion to about 600° F., which adds about 20 per cent to the economy.

As compared with producer-gas the cost of installation is less. High temperature can be readily obtained without regeneration, and the loss in gasifying is eliminated.

The cost of operating a powdered coal plant having a capacity of 5 tons per hour or 50 tons per day is approximately as follows:

10 Hour Turn.

100 H.P. @ 1 cent per H.P. hour	$10.00	
1 man @ $2.00 per day 1 man @ $3.00 per day	5.00	
1,000 lbs. of coal based on 5 to 8 per cent moisture	1.00	
Waste and repairs	3.00	
	$19.00	
50 tons milled		$0.38 per ton
Conveying to furnaces:		
1 man	$2.50	
Power, 15 H.P. @ 1 cent	1.50	
	$4.00	
For 50 tons		$0.08 per ton
Total cost of milling and conveying		$0.46 per ton

The average cost of gasifying one ton of coal, based on the average cost of four large concerns operating a number of plants located throughout the country, is 59.25 cents.

Regarding kinds of fuel, it is not necessary to use cheap or poor grades of coal in order to make savings. The analysis of the fuel and heating value should be considered, a high volatile, low ash and low sulphur being the most desirable.

I am very sorry not to be able to give you actual figures as to the results obtained in open hearth practice, but the plant being installed for the American Steel Foundries at Sharon, Pa.,

works is not quite completed. The results obtained by the Sharon Steel Hoop Company were so successful that they are now operating three open hearth and equipping the balance of the plant. The ash accumulating in the checkers has given them very little trouble and the effect of sulphur is no more noticeable than with producers.

Coal, dry, fine, fed uniformly and burned at low velocity which produces the least wearing effect upon the brick work, apparatus for intelligently determining furnace conditions and

FIG. 9.—PLATE HEATING FURNACE SHOWING MOTOR DRIVEN CONTROLLER AND BINS SUPPORTED FROM FLOOR, PERMITTING CRANE TO OPERATE OVERHEAD.

preventing waste, such as weighing scales, CO_2 recorders and pyrometers, should be provided so that the operation can be accurately checked and guess work avoided.

From this it will be seen that it is not simply a question of burning, but one of economically handling, preparing or milling, distributing and burning; safety, reliability, upkeep, power and efficiency must be considered. I believe I am justified in advocating the best and strongest designed machinery, well ventilated drying and milling plants separate from the main building, the handling of the coal in dust-tight covered screw conveyors,

automatic stops on conveyor lines to prevent jamming when bins are full. Not the distribution of powdered coal with fans or mixed with a sufficient amount of air to support combustion or to form an explosive mixture. In other words, the entire

FIG. 10.—FORGE FURNACE—HEATING WORK FOR DROP HAMMERS. POWDERED COAL EFFECTED AN ACTUAL SAVING OF OVER 48 PER CENT IN THIS FURNACE.

system should be acceptable to the most exacting insurance board as well as right from the engineering standpoint.

In considering new installations the specifications for furnaces should therefore be so drawn that when constructed they may burn powdered coal as well as oil or gas fuel.

THE PART THAT THE CARNEGIE INSTITUTE OF TECHNOLOGY PLAYS IN THE DEVELOPMENT OF MODERN FOUNDRY PRACTICE.

By Dr. C. B. Connelley, Dean—School of Applied Industries, Pittsburgh, Pa.

This is distinctly an industrial age. Every age, in fact, since man was decreed to a life of work, has been an industrial age to a greater or less extent, but never before has the spirit of industry taken the ruling hand and swayed its scepter into the high and low places and breathed its genius into so many people in so many ways as at the present time. It has brought about a change of conditions in industry itself to such an extent that many of the old landmarks have disappeared and numerous of the ancient traditions and customs attached to it have given place to the new leavening influence that is permeating it all.

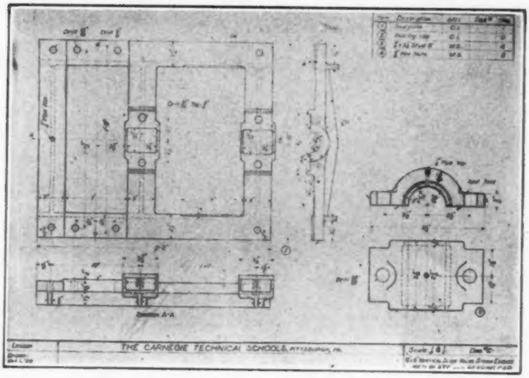
No longer does the master hand down to the apprentice and journeyman the traditions of his art as was the case in the olden times. The word masterpiece which derived its origin from the custom whereby the journeyman became a master by the execution of a masterful piece of work—whether it be "the lovely lantern or scroll, the blazoned shield, the large cylinder, the rolling mill housen," etc.,—now appears in an altogether different setting. In our times the strong prejudice that existed against the man who entered the field of industry, by other than the beaten path of shop apprenticeship is rapidly waning and in most quarters has been obliterated entirely.

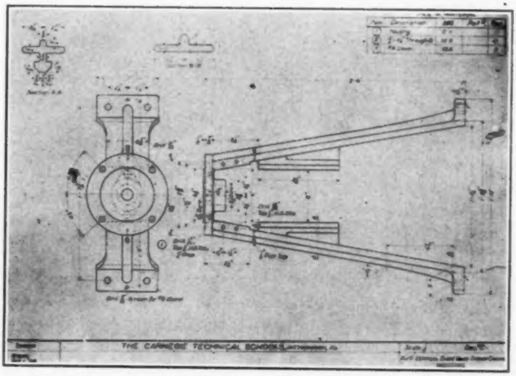
No better acknowledgment of the change that has taken place can be found than in the purpose of just such an organization as the American Foundrymen's Association. The object of this Association, as I understand it to be, is, "to advance the interests of the foundry operator; to collect information connected with the foundry business; and to exchange experience and

encourage uniform customs and actions among the foundrymen." And, indeed, if there be one industry which, by reason of time-honored prestige and of increasing service to the world in this age of invention that should advance with the times, it is the foundry industry. The paramount problem which you have to solve is, "How can we get men of the right stuff in anything like the numbers that the increased demand requires?" The answer must come back to you in terms of the very spirit of the times. An industrial age demands industrial education. At the very outset this organization is to be congratulated for the stamp of approval it has put upon the type of education that really fits one for life as we know it. You are to be commended for your choice of the able men whom you have placed at the helm as chairman of Industrial Education Committee and secretary of the Association. Their unflagging interest and devotion in this live issue will make many a man, numerous boards of education, and as many institutions of learning rise up and call them blessed. Their kindly practical interest in the development of the Carnegie Institute of Technology brings upon this occasion a sincere and unsolicited acknowledgment of service that has been extremely helpful.

As an exponent of industrial education in its superlative sense, the Carnegie Institute of Technology, by reason of its abundant endowment and splendid equipment, is in a position to occupy a place of leadership which can only be hindered by the attitude of the industries themselves. Mr. Carnegie, in founding the Institution of Pittsburgh, an industrial center, had in mind the practical instruction of the sons and daughters of workers in the mills and factories in that vicinity.

Under the direction of Dr. Hammerschlag and his executive staff and the eight prominent citizens who form the Committee on the Institute of Technology, the institution has had a phenomenal growth. In the present plant there are six commodious buildings, either in use or in the process of construction. The enrollment of students has increased gradually from the time it opened its doors to students in October, 1905, with 120 students, until the present school year, which starts with 3,100 students gathered from all parts of the globe. Under the general title—


THE CARNEGIE TECHNICAL SCHOOLS, PITTSBURGH, PA.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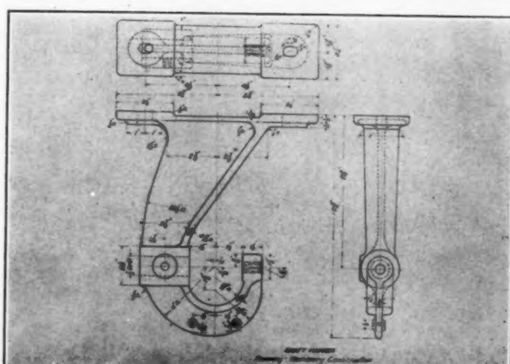

Carnegie Institute of Technology—it comprises four distinct divisions or schools, known respectively as:

(1) The Margaret Morrison Carnegie School for Women, which is intended for the instruction of women for the home and for commercial and professional positions:

(2) The School of Applied Design, which is co-educational and is for the education and training of students in art and design, offering courses in architecture, interior decoration, music, drawing, painting and illustration;

(3) The School of Applied Science for men only, who wish to become electrical, chemical, civil, commercial, metallurgical, mining, or sanitary engineers;

(4) The School of Applied Industries, for men only, furnishing an industrial education in machine construction, building construction and in general equipment and installation, adapted also to equip mechanics for more advanced positions in their chosen lines and furnishing a substantial preparation for men to become teachers in manual, vocational and industrial training.

The School of Applied Industries, on account of its provision for the trades for men, occupies a unique position in the education of this day. It not only teaches the various trades, but seeks to inculcate these principles of civic duty which make for good citizenship—a necessary adjunct to education in its fullest sense.

It is more than a mere trade school, for in addition to giving practical instruction in the chosen trade or vocation, it offers a broad training along fundamental academic lines which dovetail in with the practical. It takes the so-called cultural and mixes it with the practical and both lose their stiff-back identity in a better trained worker, and a more useful type of citizen. It is this type of education that gives the average American workman the poise and bearing that he can, as has been well said, "wear a dress suit with as much ease and grace as he can his suit of overalls." As a general proposition, the training fits one for a position of foremanship along the mechanical and building lines.

The school is open to both day and night students and so caters to all possible types of earnest manhood. The purely nominal fees make it possible for almost anybody to pursue a course along industrial lines. Recognizing the fact that all

SCHOOL OF APPLIED INDUSTRIES, OF THE CARNEGIE TECHNICAL SCHOOLS. CLASS IN PATTERN MAKING.

trades can be classified either as mechanical or as building, the courses are arranged accordingly. Under the heading of mechanical trades, being of particular interest to an organization like this, the course offered in our day school is known as Machine Construction. To be more explicit, it consists of instruction in the theory and practice of allied occupations, including machine, pattern, foundry, forge work and mechanical drafting. The practical training is supplemented with instruction in mathematics, physics, chemistry, English, commercial geography, civics, industrial history, estimates and costs and economics. This is arranged on a basis of three-year course, the first two years being concerned with practice in the allied shops with the necessary academic studies, and the third year is for specialization along the particular line of most interest to the student, whether it be in machine shop practice, mechanical drawing, forge, pattern, or foundry practice. It can readily be seen to men who are interested in the foundry that such a comprehensive training ought to turn out a broad-gauged foundryman, familiar with every detail of the business. But, of course, it must be understood from the beginning that the graduate is no more a foundryman in the commercial sense than is the graduate of a law school a lawyer, or of a medical school a doctor, or of the theological seminary a preacher. Only real experience in the outside shop in touch with outside business and professional world can give the higher finish to the skilled worker, and foreman, or professional man.

From the very inception of this particular industry in the School of Applied Industries of the Carnegie Institute of Technology, we took the stand, as is aptly expressed by Director Hammerschlag: "To make better foundrymen, make better molders and to give foundrymen what is their just due in the commercial world." Much attention, therefore, was given first of all to the construction of the school foundry. For, as Thomas D. West says, "When a man is about to construct a foundry, he cannot give the matter too close attention. Let him make lines and rub them out again until he gets something that fills his ideas; then make three or four tracings, and submit them to as many practical foundrymen with the request that they find all the fault with them they possibly can. Then, with a mind unprejudiced, let him consider their opinions, and adopt whatever is

BREAKING TEST BARS FOR TRANSVERSE STRENGTH.

good." Such a plan was carried out to the letter, and a look into the shop will convince every practical man of the result.

The foundry is housed in a spacious well-lighted and well-ventilated room 70 x 50 ft., occupying an entire wing of the Applied Industries Building. A gallery 10 ft. wide extends around the entire inside of this wing. The ground floor is used for floor work, such as loam and dry sand, sweep and heavy green sand molding; the gallery is used exclusively for bench work and demonstration of molding machines. A room 14 x 15 ft., with shelves and racks, is used exclusively for pattern storage. Another room is now being added which will serve as a storage for materials and flasks.

The equipment comprises twenty-five benches for bench-molding with all necessary tools, such as shovels, sieves, rammers, lifters, vent-wires, brushes, bellows, rapping bars, gate-sticks, draw-spikes, wet-brushes, parting-sand, shakers, dust-bags and gate cutters.

There are also a great variety of flasks for floor-molding, with all necessary tools for this work; iron flasks for dry-sand molding, sweeps and sweep-stands for sweep molding, bench for core making; core-boxes, rods, clamps, core-plates, etc.; 5 x 5 ft. pit, one 6 x 6 ft. core-oven; one oven for dry-sand and loam molds.

There is one 42-in. cupola for general shop work, the blast for which is furnished by an electrically driven fan, the charging platform is equipped with an automatic stop elevator, motor driven; one 24-in. tilting cupola for general cupola practice; one 20-in. cupola for experimental practice; one Swartz melting furnace, and one "Steele-Harvey" crucible tilting furnace for copper, brass and other alloys; one 20-in. crucible furnace for the melting of steel, titanium, vanadium, and other experimental alloys; and one "Monarch" ladle heater. The furnaces and ladle heater are equipped for gas and oil, and the blast is furnished by a direct-connected No. ½ Garden City positive blower; one motor-driven 30-in. tumbling barrel for the tumbling and cleaning of castings; eighteen hand ladles, four shank ladles, and one 800 lb. crane ladle. Five molding machines form part of the present equipment of the foundry and are of the following types: One Herman jarring machine; one Tabor roll-over machine, one Tabor and one Webb squeezer, and one machine of the stripping plate variety. One motor-driven centrifugal sand mixer, one motor-driven 18-in.

CLASS IN FOUNDRY PRACTICE.

emery wheel, one Hauck oil burner for drying molds, are some of the other appliances of this department. For the handling and lifting of heavy materials and molds and the pouring of iron, a Brown electric traveling hoist of 400 lb. capacity is installed in the foundry, bringing the equipment on a par with any well-equipped commercial establishment.

The very appearance of the foundry and the up-to-date equipment, on a par with the best of the commercial shops, is in itself a mute object lesson of what the foundry really is and the important part it plays in the world's industries. When it is known that hundreds of young men, industrially inclined, spend a considerable portion of their time in this shop and hundreds of others, professionally inclined, for all students in engineering of the School of Applied Science are required to spend a certain portion of the first seventeen weeks of their schooling in the foundry as fundamental to their after-training, it is evident that impressions are being made which cannot help but reflect creditably upon the foundry, as an important link in the work-a-day activities of the world. Then, the fact that prospective teachers of industrial education in the public schools or higher vocational schools get shop training in this foundry makes it a factor in promoting something like ideal conditions from an educational standpoint.

There is scarcely a day that some visitor, or group of visitors, from all parts of the world, make this shop the objective point of their sight-seeing, and the oft-heard expression, "Well, this looks like a real foundry," the echo of which must surely ring out and fall upon responsive ears. During the annual exhibition night, when the work of the students is on exhibition and the shop is made to show up in full blast, thousands look on with interest and admiration. Thus the general appearance of the school foundry is preaching a message and giving the industry itself a healthful publicity so necessary to the development of modern foundry practice.

The course as outlined for day students may be stated briefly, as follows:

First Year: Bench molding, core-making, the use and advantage of match boards for duplicate work, with lectures on

MACHINE SHOP.

materials such as molding sands, core-sands, partings, core-binders, tools, their care and use, etc.

Second Year: Floor molding, sweep work, open sand work, lectures on dry sand, loam molding, cupola practice, cleaning of castings, etc.

Third Year: Operation of cupola, brass furnace, melting of brass; operation of molding machines, making of ornamental castings; lectures on chilled and malleable castings; steel castings, non-ferrous metals, mixing of irons; shop management, such as cost-keeping, etc.

This along with practice in the shops of the allied occupations and with instruction in the chemistry and physics laboratories, together with the basic academic studies as previously stated, make up the curriculum of the day student. These students for the most part are young men who have had no previous experience in the trades, and it is no wonder that men with the natural adaptability for work such as the foundry offers, are attracted and won to devote their life to its furtherance. For more mature men, who have been previously engaged in the foundry and who desire to advance their interests, a short intensive trade course is offered, which consists of much work in the foundry, supplemented with a certain amount of mathematics and mechanical drawing. The instruction in every case is aimed to develop an inquiring attitude on the part of the student. If an imperfection becomes evident in a mold or a casting the student is led to inquire *why* this is, whether the fault lay with the sand, the ramming, the heating or what not. In other words, the student is not only taught *how* to do a thing and thus becomes a *skilled worker*, but he must know the *why* and *wherefore* and so become a *thinker* as well.

The night students who take up foundry work, as a rule, are more or less experienced in the trade. The night course is pitched along the same lines as in the day school with the exception that students spend little or no time in the shops of the allied trades. A particularly fascinating course offered at night is that which is known as the Foundry Foreman Course. This is designed to illustrate in a systematic way the variation in the properties of metals due to the variations in chemical composition or to other conditions at the command of the foundryman.

BENCH MOLDING.

The course of instruction offered includes a study of the quality and quantity of various substances used in foundries; the effect of silicon, sulphur, phosphorus, manganese, combined carbon, graphite carbon, etc., on the properties of cast iron; methods of melting and testing iron; making malleable and chilled castings, steel castings, brass castings, etc.

Different mixtures of iron, planned to illustrate the effect of each variant, will be melted in a small cupola, cast into test cars and tested in different testing machines and by other methods, in order to secure a complete record of physical properties in each case. A course of lectures on the metallography and composition of cast iron is also given. This course is indeterminate in length and is offered to night journeymen only.

A feature of the instruction offered in this school of real value to future journeymen is the emphasis that is laid upon safety and accident prevention. The Institution has taken an advanced stand upon this important matter no less than three years ago and the results attained have been highly gratifying. During the first year and a half of the school's existence, eighty-four accidents are recorded, six of which occurred in the foundry. A systematic campaign was inaugurated by the faculty against this evil with the result that a Safety Appliance Committee was appointed in 1910, which consists of practical shop men who suggest remedies, an academic member of the faculty who acts as secretary, and an instructor in mechanical drawing who devises and lays out on paper the necessary improvements. This committee makes frequent visits to the various shops and thus far has suggested sixty-seven safety appliances, at a total cost of $2,500, most of which have already been installed, the foundry receiving its due share.

During the last two years but twelve accidents have been reported, one of which happened in the foundry, and in the last year but two accidents occurred, none of which was in the foundry. The instructor in foundry practice, as all shop instructors, includes in his regular lecture helpful talks on safety, pointing out that care and education along this line are of more real worth than the safety appliances, and cautioning safety first, last and always.

Of more than passing interest as well is the fact that an

THERMIT WELDING.

MOLDING AN ORNAMENTAL BRONZE CASTING.

intimate and sympathetic relationship exists between the various manufacturers of the city of Pittsburgh and the School of Applied Industries. This has an extremely wholesome effect upon the students as well as upon the work that the school is doing. This is maintained by the manufacturers co-operating to the extent of appointing committees to advise the working out of the curriculum. Among the organizations thus co-operating are the Pittsburgh Foundrymen's Association, and the Molders' Association. Major Speer, the past president of your Association, appointed his first committee from the Pittsburgh Foundrymen's Association to co-operate with the Molders' Association to work with us on our course of study—as did also certain well-known firms engaged in the foundry industry. Just recently committees have been appointed by the aforementioned associations as well as the foundrymen's local union who are waiting for the call of the Dean of the school to work out further plans for the school foundry. It can be mentioned, too, that of two members of the Committee on the Institute of Technology, one, Mr. William McConway, the chairman, is a foundry owner, and the other, Mr. W. Lucien Scaife, was formerly identified with the foundry industry. These men make frequent visits to the Institute with the objective point in view of seeing to it that the foundry maintains its standard of efficiency.

In conclusion, then, it must be evident that the foundry of the School of Applied Industries of the Carnegie Institute of Technology is interpreting the meaning of foundry practice in a manner in keeping with the age in which we live. It is doing its share in serving as a clearing house for the publicity of what a model foundry should be; for the securing of a new and better type of foundrymen; for creating a sympathetic interest of what the real work of a foundryman is; for inculcating the idea of safety and accident prevention; for bringing together practical foundrymen to work out the problems of future men for the trade; in short, in the words of the American Foundrymen's Association, for "encouraging uniform customs and actions among present and future foundrymen."

Thus the Carnegie Institute of Technology is playing its part in the development of modern foundry practice.

APPRENTICESHIP SYSTEM IN THE METAL INDUSTRIES.

ADDRESS BY M. W. ALEXANDER, LYNN, MASS.

Are you, who are employers of men, entirely satisfied with the present condition of industry as it affects your ability to get the right kind of labor, both in respect to quantity and quality? If you are, then my task this afternoon will be comparatively easy, for I need to indulge only in congratulations on the auspicious conditions under which you are permitted to carry on your businesses. If, on the other hand, you should, as my experience has shown me you must, answer this question in the negative, then I beg to submit this other query: Why did you permit the present unsatisfactory conditions of labor to develop, and what are you doing today, and more important still, what are you determined to do tomorrow to bring about the desired change?

On the directness and the character of your answer to this question hinges, in a large part, the solution of the important problem of the adequate supply of competent men, as the answer itself will clearly show whether American employers in the foundry and allied interests have finally awakened to the realization of the seriousness of the condition, and are concluding that, as in all other matters, so in this, the only way to do a thing is to do it and to do it right, rather than merely talk about it. But in the doing of it we must, of course, proceed along wise, practical, well-thought-out lines which have their roots in the study of the past, and which in their daily lesson of achievement point to ultimate success in the future. It would seem almost needless to add that these lines, definitely conceived though they be, should be so flexible that they can follow, without losing their character, the ever-changing industrial conditions, which in turn are necessitated by the changing social and economic aspect of the industrial life of the day.

Let us for a moment look back to the past. We remember, no doubt, the time when the guilds had their sway and when no one could enter the ranks of the craftsmen and lay claim to such a title unless he had gone through a regular, well-conducted apprenticeship in his particular trade, and at the end of it had proved by the making of a so-called "masterpiece" that he was worthy to be counted as a member of the craft. And only as recently as forty or fifty years ago such conditions existed in the labor situation. Then the employer realized his responsibility in the matter of developing his own skilled helpers, and each one of them sought at least one or two apprentices for himself whom he could train in the mysteries and arts of his trade.

What, then, has brought about the change from the time of but forty or fifty years ago, when little complaint by the employers was heard in respect to their ability to secure skilled labor? Two main factors present themselves for consideration: Industry developed rapidly in the direction of specialization, and as the character of specialization became more and more pronounced, employers, who, though otherwise very sagacious, were evidently short-sighted in this particular respect, came to believe that the need for the well-trained, all-round skilled mechanic in any of the trades was less urgent than it had been in the past. They did not realize that the greater specialization of the industry, and with it the greater utilization of unskilled, and untrained masses, required a higher type of men to lead and direct this ever-growing army. They did not remember that the more complex machinery, through which, at least in part, specialization was made possible, also called for a higher type of all-round trained men for its designs, its construction and maintenance, and in many cases even for its operation.

The other factor which came into play was the public school system. The new idea of manual training had become an important element in the public school system, and employers now readily shirked their responsibility for the training of craftsmen by shifting this burden upon the public schools. Yet careful thought would have made these employers see that the public schools at best could not respond very quickly to the new demand, and certainly could not follow very closely in their methods and curriculum the many changes brought about by the rapid development

of industry that began at that time and has continued to the present day.

It was in the city of Chicago in 1893 that the manufacturers of Europe, and particularly the Germans, displayed the products of their high manual dexterity, and thereby showed to the American manufacturers that the latter would have a hard fight on their hands in an effort to conquer and maintain the markets of the world in competition with European manufacturers. It was in Chicago, I believe, that the thought was born anew among employers that only through a revival of the apprenticeship system, modified to suit the new industrial conditions, could they secure the superior intelligent skill through which they could fortify themselves in the industrial struggle that was to come.

Some splendid examples of apprenticeship have since been developed, but they are evidently but little known among the people at large; many academicians still cherish the idea that the apprenticeship system in this country is dead and that we must turn to the public school system as our only hope for the development of trained mechanics. The story of the many successful apprenticeship systems throughout the land should, therefore, be emphasized again and again before such associations as yours and before other bodies of thinking men. But it ought to be stated with equal emphasis that far too little is as yet being done by the employers in this field of practical trade training. Indeed, it is surprising that sagacious American business men have paid so little attention to this matter in the past, and are not even today doing more for the protection of their own industries and those of the country, by developing an adequate supply of properly trained labor, skilled in the activities of our industrial life.

To my mind the public school system must more fully take cognizance of the changes which are converting our country more and more from an agricultural to an industrial country; the schools of the future will, therefore, have to train the great majority of the youth not only in the instincts of good citizenship, but also to become self-supporting citizens when they enter the industry and commerce of our country. For reasons too obvious to mention the process will of necessity be slow, but in any event the public school systems will be able to go only a limited distance in this respect. While they may, for instance, eventually train

boys in the general principles of the art of molding, they cannot be expected to fit them for immediate efficient service in any particular line of the foundry industry. Then, as now, it will be the function of the employer to apply the finishing touches; now, however, he must also attend to the preparatory work of training. Then the apprentice course will become a short finishing period; now a thorough apprenticeship system of several years seems needed.

While this process of educational rearrangement is going on let us, as your Committee on Industrial Education has so well pointed out, stretch out our helping hand to the well-intentioned educators who are trying to bring about this change in the conception of public education. In the meantime, also, let us not forget that the industry of today and the industry of tomorrow demand competent forces to man the shops and machines and to do all the other things that the industrial life requires; and let us remember that it is essentially up to us to see to it that this is done.

In response to the invitation of your associations, I shall place before you an example of practical industrial training through an apprenticeship system, but in doing so I have no thought of exploiting in particular the details of the system of which I shall speak. In putting before you a concrete example of achievement in this field I rather wish to point to certain underlying principles that have guided the work and made it successful; and on this basis I hope to indicate to you how these principles along the same or similar lines may be applied to your own businesses.

It was in 1902 that the General Electric Company at its works at West Lynn, Mass., employing at that time about 4,000 men, established a new apprenticeship system. This step was the outcome of a study of the reasons for the seeming failures of then-existing apprenticeship systems. Very briefly enumerated they are these: Under the old form of apprenticeship a boy was taken into a shop and turned over to a foreman who was expected to teach him the trade. If there is any class of people in our industries that are hard worked it is our foremen. They are constantly driven by production requirements, their cost of production is constantly attacked, and they should not be expected

to take the time or to have the particular inclination, to initiate green boys into the trade. It therefore usually happened that the foreman would turn the apprentice boy over to an assistant foreman, who in turn would pass him down the line until he landed in the hands of a perhaps well-meaning mechanic, skilled in his trade, but seldom possessed of the ability to impart his knowledge to his pupil. As I have often said, the greatest art, it seems to me, is the art of teaching. How many are there even among the professional teachers who can in the truest sense of the word be called great teachers? The foremen, their assistants, the mechanics have not been trained along pedagogical lines, nor have they been selected with that object in view. Occasionally one may be found who is doing splendid service in the training of others, but he is the exception rather than the rule.

Then there was this other difficulty, that the conditions of work in one department to which apprentices were assigned differed quite materially from those prevailing in another department, where the apprentices, therefore, did not receive as effective a trade training. Even in the same department the conditions often changed from month to month or week to week, and the instructive work of yesterday was today replaced by repetition work without much instructive value. The apprentice became, therefore, the victim of the daily or weekly productive requirements of the shop. To overcome this difficulty apprentices were placed under special supervisors, whose function it was to transfer apprentices from one department to another in order to give them an equal chance and a broad opportunity for training. To the extent to which the supervisors of apprentices could harmonize the viewpoint of the employer with that of the apprentices, they would fulfill their dual function with satisfaction, but the practical conditions in the various departments often prevented the supervisors from doing full justice to their task.

Finally, in our industrial struggle of today, quite different from that of twenty-five or fifty years ago, it has become more and more essential for those who wish to rise above the average employee, not only to be able to do their work well, but also to possess an intelligent understanding of the work on which they are engaged and an imaginative outlook as to the possibilities for better and more efficient work. Again, employers began to

acknowledge this necessity and consequently they at first requested and later required their apprentices to obtain adequate classroom instruction in the public evening schools of the community, or through other educational opportunities. Some apprentices followed these instructions willingly and others did not, but neither of them could get the full value from the time so spent, for after eight, nine or ten hours' daily work they were not in proper condition for such evening work.

Realizing, then, these various factors that had made in large part for the failure of apprenticeship systems, the General Electric Company started out on new lines. It first established in the Lynn factory a special department devoted exclusively to the initial training of apprentices, and placed that department under the charge of highly skilled men whom nature seemed to have endowed with the faculty of teaching others, and who took a great delight in doing so. Classrooms were then built in connection with this training room and every apprentice was required to devote a part of his regular working hours to the work in the classrooms, where he was instructed in the technical principles that he ought to know for a better understanding and a more intelligent grasp of his work; at the same time an effort was made to teach an objective as well as a subjective viewpoint of the relationship of employer and employee, in order to develop greater loyalty to the work and to the man in charge of it. Apprentices in the training room were given only work of a commercial character, which would have to be done by others in the factory if it were not done by these apprentices; in this way it was aimed to train apprentices in industry for industry.

From a modest beginning of one training room in 1902, about 30 x 40 feet in size, located in an available corner of an old factory building, the system grew step by step and in keeping with the growth of the Lynn works, which today employ about 13,000 people. There are now located at Lynn apprentice training rooms for machinists and tool-makers, for pattern-makers, and for foundry workers. The latter, I must confess, is at present entirely inadequate in size and scope, but will receive closer attention and develop more largely in the near future. The training room for pattern-makers now occupies a space of about 6,000 square feet, with an adequate equipment of wood-working

machinery, while the training room for machinists and toolmakers is located on the top floor of a modern factory building, where it covers a space 80 feet wide and 450 feet long or 36,000 square feet. In this training room is found a very complete equipment of the machines usually needed by the mechanic, representing approximately an investment of $100,000.

The same system, suited to the size of the plant, has meanwhile been extended to other factories of the General Electric Company, where in all between 1,500 and 2,000 apprentices are constantly under training. It has also found entrance into other industries and railroad shops in various parts of the country, modified here and there to suit local conditions and personal considerations.

Let me now briefly outline the conditions under which boys are accepted as apprentices. Until October first, any boy over fourteen years of age who was normally developed, had a pronounced desire for the trade which he wanted to learn, and had successfully finished a regular grammar school course, was eligible as an apprentice. In a few instances boys were accepted who had not fully completed the grammar school course and could give adequate reason for their incomplete education.

We realize fully that many a boy who has only gone through the seventh or the eighth grade of the grammar school, but did not graduate for one reason or another, may develop into a far better mechanic in the foundry, the machine shop or in the pattern shop than another who has completed the prescribed school course and received a certificate of graduation. Yet, in dealing with large numbers of apprentices we must of necessity deal with the whole problem in a more systematized manner; by insisting, therefore, on a completed grammar school education we feel safer in starting our educational program on the basis of such educational preparation by all apprentices. We have this other object in mind, however, in expecting a boy to have graduated from the grammar school before entering one of our apprenticeship courses, that in this way we assist the public school authorities in holding the boys to the end of the school course, so that they may learn there, as they can better learn in the public schools than in the manufacturing establishment, not only the fundamentals of education but also the instincts of citizenship, and may

obtain at least to a small degree that general cultural background that adds so much in later life to the enjoyment of life itself. Aside from the selfish standpoint, therefore, in obtaining a better educated class of boys for our purposes, we are showing our effort for co-operation with the public school authorities, on whose co-operation in turn we have to rely to some extent in the successful carrying out of our own educational work.

On October 1, 1913, a law went into effect in Massachusetts which forbids the employment of any boy or girl under sixteen years of age for more than eight hours a day in any industrial establishment, and otherwise restricts employment of such minors. Inasmuch as the law would not deduct the hour and a half daily school work in a consideration of the working hours of our apprentices, we were forced, much against our will, to take the stand that only boys of sixteen years or more, as far as the Massachusetts factories are concerned, would be eligible for apprenticeship training. Every boy accepted for training must first successfully complete a trial period of two months, but the two months of time so served are considered a part of the whole apprentice period. This period has been set at four years for machinist and pattern-maker apprentices; foundry apprentices are required to serve two years, although they are strongly urged to continue during a third year of specialized foundry training. Those apprentices who are being trained for future efficient draftsmen and designers, testers of electrical and steam machinery, installation and erection engineers, and for other technical positions, are required to serve an apprenticeship of three years; this class of apprentices must have had a complete high school education in order to be eligible.

It used to be the accepted practice, prevailing in many establishments even today, that the first work to be given a green boy starting as an apprentice was the sweeping of floors or the running of errands. I am the last one to belittle the value of these classes of work. When a man wants to take effective charge of others, he will be the more proficient in his leadership if he is familiar with all the details of the work of the other men; if he, therefore, has himself learned how to sweep and how to carry messages effectively, he will be in a better and more authoritative position to enforce proper performance of such functions

by the men under him. I submit, however, that the sweeping of floors and the running of errands is work that ought not to be required of an apprentice at the beginning of his apprenticeship period. When little Jimmy comes to us with the intention of learning the foundry trade, it should certainly be our first duty and endeavor to find out if little Jimmy has native ability for the chosen trade, for if there is no embryo foundryman in him it will not be feasible for us to develop one out of him, even though Jimmy may be ever so good a sweeper of floors and may carry messages ever so effectively, even as Rowan carried his message to Garcia. Our first duty, therefore, must be, it seems to me, to put little Jimmy at once at work in the trade in which he desires to become proficient, and to watch him carefully in order that we may make up our minds whether it is worth while, both in the interest of the boy and ourselves, to train him in that particular trade. If we find him to be good material, with native ability and the right attitude toward work, then it is time to show him how to sweep floors and how to carry messages. When little Jimmy, therefore, starts work with us at seven o'clock some morning, he is immediately put to work in the core room or at a machine, as the case may be, where he is carefully observed by competent men who, on account of their experience with thousands of other boys, are quick to detect, and capable to decide, whether or not to continue the process of training the particular boy in the particular trade. If little Jimmy does not give well grounded hope for future success in the chosen trade, he is advised to take up some other line of work for which he would seem to be better fitted. If, however, he gives that hope, he is permitted to sign the agreement which must be countersigned by his father, mother or guardian, which stipulates the number of years of training and the wages to be paid during that time. The agreement does not abound in "whereases," but in plain language says to the apprentice that for a certain number of years and at a certain wage the company will endeavor to teach him the trade and develop his intelligence simultaneously in classrooms, while he, on the other hand, promises to perform the work that is given to him in a satisfactory manner, to obey the usual factory rules, and to deport himself at all times to the full satisfaction of his superiors.

At the time of signing the agreement the apprentice is plainly told that the agreement has, as a matter of fact, no binding force, so that the company could not, even if it should desire, bring him back to the performance of his agreement if he should break the same by leaving his employment with the company. To scare an apprentice through a legal agreement with supposedly legal force and resultant penalty of the law for the breaking of such agreement, will always prove a wrong psychological step, and is likely to arouse from the beginning an antagonism in the boy; this will not be the case when the agreement is placed before him not as a legal document, but as an agreement of honor between two parties. Our experience has shown the correctness of this viewpoint, and our statistics show a remarkably small number who "jumped" their agreement during the last ten years. Nevertheless, there have been cases where, for instance, a boy of a certain locality or of a certain nationality did break his agreement, with the result that other boys of the same locality or same nationality followed his example. These cases, as already stated, have been remarkably few. When the superintendent is unable to persuade the boy of his wrong-doing in breaking the agreement, except for very good reason, when the agreement should be cancelled by mutual consent, such apprentice is generally brought to me. My conversation with him is usually short. After listening to his reason for wanting to leave the employ, I remind him of our earlier statement that the agreement has no binding legal force, and that it is merely an agreement of honor. "You have given your word as a gentleman, and I believed you to be such when I accepted you as an apprentice, that you would fill your part of the agreement; we gave, similarly, our word that we would fulfill our part." My conversation continues: "Have we paid you the wages which we promised in the agreement, have we endeavored to give you a proper training, and have we treated you properly in other respects? If so, then we have fulfilled our part; if not, you have good ground for complaining to us but have not yet the right to go back on your own word. On the other hand, are you justified in breaking your word because you do not like now the condition which you voluntarily agreed to when you started as an apprentice, or because you are able to get a position somewhere else at perhaps a slightly higher compensa-

tion? Would not such action place you, after all, in the same class in which a friend of yours would be whom you loaned $5 to help him in an embarrassing position, and who, though he promised to return the money within a week, at the end of that period concludes that inasmuch as no binding agreement had been drawn up between you and him relative to the loan, he would rather keep the $5 than his word? Go home and think the matter over. If you feel that you are on the point of doing a wrong thing come back to work the next morning and nothing further will be said about the incident. Should you, however, still insist in pursuing your wrong course, then stay away, and my only regret will be that I made the mistake of ever engaging you, for I evidently considered you a man of your word when as a matter of fact, as you now prove, you should not have been so considered."

Some of these apprentices come back and others stay away for good; those, however, who do come back will, I am sure, be leaders of men some day. They have learned their lesson.

The apprentice agreement, as I stated before, stipulates the wages to be paid during the apprenticeship period. Years ago we decided to establish a higher apprentice wage scale than was then prevailing throughout the country, so that even the boy of a poor family would be enabled to come to one of our factories to learn a trade and at the same time support himself.

On this basis we are paying machinist and pattern maker apprentices an initial rate of 10 cents per hour, or $5.40 per week, payable also during the trial period and for the time spent in the classrooms; this rate is gradually increased in amount until it reaches 16½ cents per hour during the fourth year of apprenticeship. These apprentices receive an appropriate diploma and a cash bonus of $100 upon satisfactory completion of their apprenticeship term.

Similarly, iron and steel molder apprentices whose initial rate until recently was also 10 cents per hour, are now receiving 14 cents per hour, or $7.56 per week at the beginning, with an increase to 18 cents per hour for the second year and 20 cents per hour for the third, optional year. The cash bonus in this case is $50 for a two-year period and $75 for a three-year period of apprenticeship. These molder apprentices must be at least 18 years of age to be accepted for training.

The justification for the payment of wages for time spent in classrooms lies in the fact that we require apprentices to go into the classrooms for an hour and a half every day except Saturday. With this arrangement, then, we do not deprive apprentices of any money which they could otherwise earn for themselves if they would remain all the time in the foundry, machine shop or pattern shop. Inasmuch as many of them had left the public schools at the end of the primary or during the early part of the secondary school period, because the commercial spirit to earn money had become too strong, we found it advisable to recognize that we could not succeed in our efforts to make intelligent as well as skilled mechanics of the boys if we would force an education upon them and at the same time reduce their weekly earnings. If, on the other hand, we take into account this natural desire for monetary gain by continuing the payment of stipulated wages even during classroom hours, we believed that the boys would be eager to go to school in order to gain additional knowledge and apply the same to the daily shop work. Experience has proved the correctness of our premises. I remember, however, that our directors looked at first with somewhat doubting eyes upon the proposition of spending a large sum of money for what might be called unearned wages; today, however, everybody seems convinced of the investment value of such expenditure, by means of which the apprentices become more intelligent through the daily correlated classroom work, and grow also more intelligent and more speedy in their daily shop work. Thousands of dollars spent yearly for greater intelligence of the apprentices on the one hand, are no doubt returned to us in greater efficiency of work on the other hand. At the same time, we are afforded an opportunity to train the spirit of the boys along sane and thoughtful lines.

In a consideration of the method of training apprentices at the Lynn works, several important phases must be emphasized. I shall attempt to do this in connection with a series of pictures illustrative of the apprentice system at the Lynn works which are now presented for the first time in this country.

The first picture (Fig. 1) shows a bird's-eye view of that part of the Lynn works in which the building in which the apprentice training room for machinists and tool-makers and the class-

FIG. 1.—GENERAL ELECTRIC COMPANY, RIVER WORKS FROM SAUGUS HILL.

rooms are located. I shall confine my further remarks largely to the training of machinist apprentices, because this phase of the work is farthest developed; yet the same principles and their application hold good in the main for the training of future foundry workers and pattern makers or other skilled and intelligent artisans.

As already stated, the first training room was established about eleven years ago in an old factory building, where it occupied a corner of about 1,200 square feet. At that time, with the aid of a skilled and ingenious mechanic and designer, who is still our superintendent of apprentices, I secured from the scrap heap five lathes, two milling machines, two drill presses, one shaper and a metal saw, all of which had been discarded by the foremen as unsuited to the productive intensity of the time. These machines were brought into the training room and the first ten apprentices were put to work to clean them thoroughly and to help the superintendent in his effort to make them operative again. Without much expense, therefore, we built up a small machine shop, adding from time to time to the equipment either by old machines which we repaired in the training room or by some new standard machine tools. Some of the old machines which were rescued from the scrap heap and repaired by the apprentices are working today in our training room, fine examples of what can be done to utilize old machinery for training purposes and at the same time to give the boys the splendid education that comes from the repairing of machinery.

When the old training room had outgrown its small quarters and a further enlargement in the old building was not possible, we moved to new and more spacious quarters in a modern factory building, where the new training room for machinists and tool-makers, and the headquarters of the Educational Department are located. The next two pictures (Figs. 2 and 3) show this arrangement, in which the large opening in the background leads to the classrooms. These pictures were taken from opposite ends of the training room, which, as stated before, is 80 feet in width and 450 feet in length.

The apprentice training room for pattern-makers located in the new pattern shop itself, may be seen in the fourth picture (Fig. 4); it is smaller in dimensions, as fewer apprentices are

FIG. 2.—TRAINING ROOM FOR TOOL MAKER APPRENTICES, APPRENTICE DEPARTMENT, GENERAL ELECTRIC COMPANY, LYNN WORKS.

FIG. 3.—TRAINING ROOM FOR TOOL MAKER APPRENTICES, APPRENTICE DEPARTMENT, GENERAL ELECTRIC COMPANY, LYNN WORKS.

FIG. 4.—TRAINING ROOM FOR PATTERN MAKER APPRENTICES, APPRENTICE DEPARTMENT, GENERAL ELECTRIC COMPANY, LYNN WORKS.

needed in that particular trade. While the machinist training room employs about two hundred apprentices during their initial stages of training, with about as many more already beyond the training room stage working in other departments of the factory, the pattern-maker training room employs only about forty apprentices.

The fifth picture (Fig. 5) illustrates the initial training of molders. Apprentices are shown at work in the core room, where they learn the first part of their trade; in the following picture

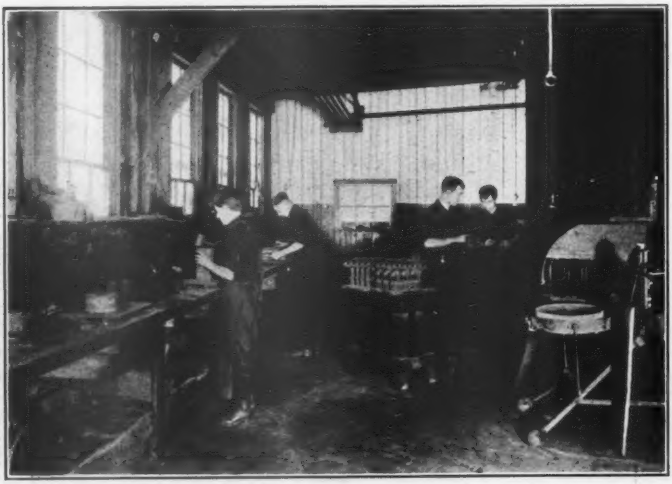

FIG. 5.—TRAINING ROOM FOR CORE MAKERS, APPRENTICE DEPARTMENT, LYNN WORKS.

(Fig. 6) apprentices may be seen at work in the foundry itself—in this case a brass foundry.

About a year ago we added an entirely new branch of training, which, although it has a more direct application to the manufacture of electrical apparatus, is interesting nevertheless as indicative of the possibilities of an effective apprenticeship system. An important part of electrical machinery is its armature and field, each carrying a certain amount of copper wires or copper strips wound upon it, which when kept in relative motion to a magnetic

field generate electrical currents in the copper conductors through the cutting of the magnetic lines by these conductors. Men who are capable of winding these armatures and fields are relatively scarce, and there are only a few places in the whole country where such men can be developed by the work itself. Yet, as the use of electricity for industrial power purposes and for electrical street railways and railways in general become more and more extended, many more expert winders will be needed both for the manufacture of electrical machinery and for the repair of such

FIG. 6.—TRAINING ROOM FOR BRASS MOLDER APPRENTICES, APPRENTICE DEPARTMENT, GENERAL ELECTRIC COMPANY, LYNN WORKS.

machinery if it should break down in service. With this thought in mind we set out to train some apprentices in this particular work, and in the seventh picture (Fig. 7) is shown the first training room for winders that to my knowledge has been established anywhere. The eighth picture (Fig. 8) affords a view of the same training room, showing in particular the testing apparatus in the foreground, where apprentices under proper leadership learn to test the armatures and fields which they have wound. In its

somewhat more advanced stages the work of these apprentices consists of the repairing of electric dynamos and other machinery as it relates to the re-insulating and re-winding of the armatures and fields.

The same apprentices receive a more extended training in the testing of electrical apparatus in the testing departments themselves. One of these is shown in the ninth picture (Fig. 9). As stated before, apprentices admitted to this kind of work must be either high school graduates or must have finished the four-year apprenticeship course for machinists and tool-makers, and have been admitted to one-year post-graduate course in the test-

FIG. 7.—TRAINING ROOM FOR WINDERS, APPRENTICE DEPARTMENT, LYNN WORKS.

ing and erecting of electrical apparatus. Without going further into detail, I merely wish to mention that the Lynn works offers also training courses for steam-fitters, and some very capable young men have been graduated from these courses and are now doing excellent work in their trade. Some apprentices are developed along specialized lines of die making; others are trained in high-grade instrument making.

One phase deserves, however, more than a passing note; it has to do with the development of young men trained in business

activities so as to become effective stockkeepers, shop clerks and technical business men of similar nature. Reverting again to the training room first illustrated, I wish to show in the next picture (Fig. 10) that corner of the training room in which the stock-room is located. The boy at the window who is seen to hand out some tools to apprentices standing outside the stock-room, and the boy standing farther back in the stock-room, are both apprentices learning business functions of industry. The importance of this work will be appreciated readily by those who realize that the

FIG. 8.—TRAINING ROOM FOR WINDERS, APPRENTICE DEPARTMENT, LYNN WORKS.

stock-keepers are essentially the men who handle the money of their employer as expressed in iron and steel, copper, brass, German silver and other materials. With the development of an efficient body of men for this purpose it should be feasible to reduce to a minimum the waste in handling of materials and that due to unnecessary accumulation of any stock. Young men so trained will also prove efficient on the factory clerical force

FIG. 9.—SECTION OF INDUCTION MOTOR TEST, BUILDING 74.

where the importance of the correctness of figures and transactions is often not sufficiently appreciated.

The eleventh picture (Fig. 11) which again illustrates a section of the training room previously mentioned, affords me an opportunity to call attention to a very important method of our educational effort for trade efficiency. In this picture can be seen two apprentices, the one endeavoring to instruct the other in the work of planing metal. The boy-teacher, so to speak, has already done planing work to our satisfaction, which means that he has done it with a fair degree of speed and with absolute com-

FIG. 10.—STOCK ROOM, APPRENTICE DEPARTMENT, LYNN WORKS.

mercial accuracy. No exact measure can be applied to that degree of speed which may be considered satisfactory. The physical development of the boy and the nature of the work itself have to be taken into account; he cannot be expected, after so short an experience with planing work, to have developed the same speed as an older, stronger and many times more experienced regular workman. In regard to accuracy of work, however, it is only fair to demand of the apprentice the same exactness as engineering

and commercial requirements demand of the regular worker. If from an engineering standpoint and from that of economical manufacture, two holes theoretically two inches apart from center to center, can vary in their location by $\frac{1}{32}$ of an inch one way

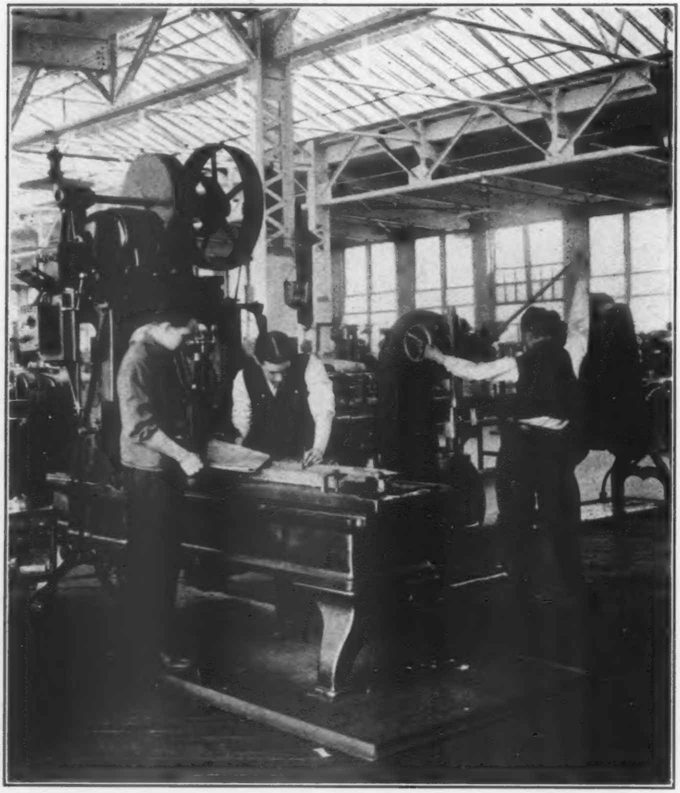

FIG. 11.—APPRENTICES AT WORK ON PLANER, APPRENTICE DEPARTMENT, LYNN WORKS.

or the other without interfering with engineering efficiency, then any relative location of the two holes within 2 in. plus $\frac{1}{32}$ in. and 2 in. minus $\frac{1}{32}$ in. will be satisfactory commercial accuracy.

Assuming, now, that an apprentice—let us call him again Jimmy—has performed his planing work with a fair degree of speed and full commercial accuracy and is now ready to take up some more advanced work, he is, whenever productive conditions permit, first utilized to assist the regular instructor in initiating a less experienced apprentice in work on a planer. "Jimmy" has, therefore, become a boy-teacher for the time being, and "Tommy" is a boy-pupil under his instruction. I am careful in using the words "less experienced" rather than "younger apprentice," for neither the age of the apprentice nor the length of his prior service as an apprentice have anything to do with placing him as a boy-teacher or a boy-pupil. It is the more experienced who teaches the less experienced apprentice; and often it is found that an apprentice of shorter service is leading one who has been an apprentice for a longer period of time. Only by carrying on the practical trade training on an entirely individualistic basis can the best results be achieved. If an apprentice needs six months to learn a particular part of his work, he will have to be kept on for that period of time; if another apprentice requires eight months for the same task, he will have to stay on the work for that longer period, and if he cannot then satisfy the instructor he will likely have to be eliminated altogether. There should, therefore, be no regular course of studying as applied to the practical work; each apprentice should be allowed to proceed with each part of his work just as fast as his native ability and his power of application to the work will permit him to proceed.

The boy-teacher and boy-pupil under the general guidance of the instructor, who starts off the team, continue together until the instructor is satisfied that the boy-pupil can stand on his own feet, so to speak, and continue in the particular work without the daily and hourly guidance of the boy-teacher. The latter is then relieved of his task of teaching and is put on some advanced work, very likely as a boy-pupil to a farther advanced boy-teacher. The value of this arrangement is obvious. First, there is the economic value of being able to instruct a large number of apprentices with a very small number of regular instructors, by pressing apprentices into service as assistant instructors along the lines just indicated.

More important, however, is the moral and pedagogical

aspect of the arrangement. Jimmy knows that he cannot advance to a better class of work until he can satisfy the instructor that Tommy is sufficiently trained to continue alone in his work; he is, therefore, anxious to teach Tommy in the best possible manner in order that he may satisfy his own ambition of advancing to better work. Tommy, on the other hand, who does not particularly relish remaining under the tutelage of Jimmy, a fellow apprentice, strains every effort to absorb as quickly as possible in order that he may continue his work without the supervision of Jimmy and eventually become a boy-teacher himself. Excellent conditions are therefore established for the one who teaches as well as the one who is taught. If Jimmy had not the ambition to instruct Tommy well in order to learn something new himself, he would likely not be kept on the apprentice course. Should Tommy, on the other hand, not absorb quickly, either because of his wrong attitude toward the work and his laziness, or on account of lack of ability, it will not be long before Jimmy will complain to the instructor, who is now in a position to investigate a concrete matter and, if necessary, either brace up Tommy or remove him altogether. Being about of the same age as Tommy, Jimmy is in a better position even than the regular instructor to understand Tommy and to size him up correctly. It does not mean, however, that a complaint of a boy-teacher will always result in the discharge of a boy-pupil; sometimes the instructor may find that the complaint of Jimmy was unjustified and that, in fact, the fault lies with Jimmy himself. Experience, however, has shown that the judgment of the boy-teacher is usually quite correct. It is rather interesting to observe a boy-teacher—boy-pupil team. Usually the boy-teacher takes very little notice of the boy-pupil when he is placed with him by the regular instructor. One of two things will then happen. One boy-pupil will respond in kind by taking neither notice of the teacher nor the work, and rather amusing himself by looking around with his hands in his pockets and getting into a general attitude of laziness and disinterestedness; he is surely the one whom the boy-teacher will report as unfit to learn the trade, and he is surely the one who will be eliminated from the course unless the warning of the regular instructor will have a wholesome effect upon him. Another boy-pupil will immediately get busy

and watch for an opportunity to help his teacher, even though he has not been specifically asked to do so. He may hand to him the tool that he will need, or may assist him in fastening shafts in a lathe dog or in calipering finished work; as soon as the boy-teacher notices this interest and activity on the part of his pupil he will begin to take a decided interest in him, and progress of the two will then be rapid.

Depending on commercial conditions prevailing in the training room at any one time, several teams of apprentices may be seen at different machines. Another one of these is shown in the twelfth picture (Fig. 12), where a boy-teacher is endeavoring to train a boy-pupil in the art of circular grinding. This particular picture permits the pointing out of still another aspect of our apprentice training. From 2,000 to 3,000 shafts of various sizes and shapes are produced weekly in the training room. These shafts are turned close to the required dimensions and are then ground to size over some portions, with allowable variations of one thousandth of an inch, sometimes one-half thousandth, and very often ten-thousandth of an inch either way. Six universal grinders of standard manufacture served this purpose in the training room until a year ago, when their capacity became inadequate to satisfy productive requirements. New machines had therefore to be bought. Upon questioning him regarding the advisability of purchasing additional grinders of the same kind, the superintendent stated that these grinders were too good for our purposes in that they were built for a greater variety of work than could be found in shaft grinding alone. As the outcome of our conversation, he sketched roughly a grinder which would, in his opinion, fill the bill and permit of high workmanship if the grinder itself were made in a high-grade manner. We then had our apprentices develop the sketches into regular shop drawings, had pattern-maker apprentices make the patterns, molder apprentices make the castings, and machinist apprentices build the parts and assemble the whole grinder. Four of these grinders, of which you see a view in the next picture (Fig. 13), are now regularly operating in the apprentice department, and we are preparing to build additional ones for other works of the General Electric Company. It is not our intention to build these grinders for the market. This grinder costs less than we would have to spend

for the purchase of a standard machine, but again this is the unimportant factor of the situation; far more important is the fact that apprentices were given an opportunity to do the work and that one apprentice was afforded the experience of taking charge of the work and of several other less experienced apprentices

FIG. 12.—GRINDING SHAFTS, NORTEN GRINDER.

engaged on the building of the grinders. The most important factor in the situation, however, seems to me to be the outlook which it afforded and still affords to all other apprentices. A new apprentice coming into the training room is soon told that the particular grinder was built by Jimmy and Tommy and other

apprentices; he therefore sees something ahead of him that he may achieve just as well as the other fellows have, and this imaginative outlook on concrete examples gives him the pleasure in his work and gives to the work itself the impetus which is so vital in achieving success. If we only could get into our primary and secondary schools and into our colleges this outlook, this inspiration, I think we would go a long step forward in getting more good

FIG. 13.—SHAFT GRINDER.

out of the boy and the young man, and in preparing him better for the work that he is to undertake after the schooldays are over.

A similar example is presented by the bench lathe which is shown in the next picture (Fig. 14), which was also designed and completely built by apprentices in the training room. Several such machines are in daily use in the Lynn apprentice training room, in other Lynn factory departments and in other factories

of the General Electric Company, and they all are giving splendid satisfaction.

The superintendent in charge of apprentices and his assistants, as already stated, are ingenious, skillful mechanicians. They desire at all times to show apprentices how to do some foundry work, some pattern-maker's job or some machine process just a little better and a little quicker than it has been done heretofore; and the boys, ambitious as they are, are always willing followers, anxious to do some new practical stunts. The instructors, however, do not usually show how to improve processes of manufacture or develop new ideas, but rather hint at it in order to develop in the apprentices as much as possible initiative, ingenuity and independent thought. Some of the new processes and methods

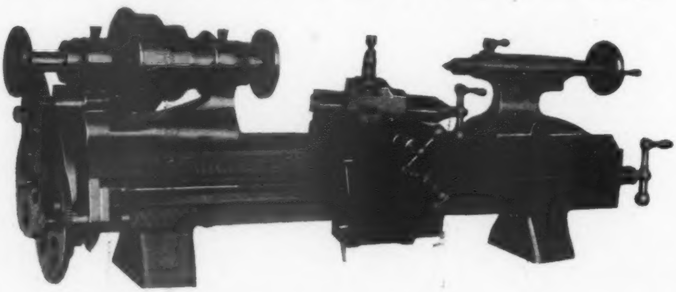

FIG. 14.—BENCH LATHE.

which have been started and thoroughly tried out in the training rooms have then found their way into other departments of the factory, where proper prices for the job could then be set on the part based on a study made in the training room, but with due justice to the fairness of wage which a journeyman should earn.

The time spent by the apprentices in their respective training rooms consumes about one-half of the total period of apprenticeship; sometimes the time is a little longer and sometimes a little shorter, depending largely on the individual capacity of the apprentice and also on productive conditions of the factory. Often foremen in other factory departments request the temporary use of some apprentices, when they return to the training room after a certain job is finished on which the help of the apprentices

was needed. While before the establishment of training rooms foremen were loath to take apprentices, whom they always considered a hindrance to production and a jeopardy to machinery, foremen are now anxious to obtain apprentices who have already received their initial training in the training room, have acquired at least some knowledge of their work, and now prove effective economic units, still under the supervision and direction of the superintendent of apprentices and his assistants. When the apprentice leaves the training room to acquire further experience and knowledge in various factory departments during the remainder of his apprenticeship period, he is practically an all-round mechanic needing a further development of skill and self-confidence and power to size up a situation and apply his knowledge to it, in the same sense in which a graduate of a professional law or medical school needs this broader experience and application of knowledge before he can become an effective lawyer or physician.

Let me revert to the statement made in the earlier part of my address, to the effect that we are endeavoring to train skillful, intelligent and loyal men. I have outlined to you our methods of making young men skillful in their chosen trade and occupation. It is obvious that these very same methods, here only briefly described, will develop loyalty in these young men. In order to make them intelligent, we require all apprentices to work in class-rooms for an hour and a half every day. It is not important whether the period is half a day, two hours or one hour each day; local conditions will determine to a large extent what is best under the circumstances. Apprentices are taught certain sciences that are more important for the proper understanding of their work. Boys who have had a grammar school education only and are trying to fit themselves for skillful molders, machinists, pattern-makers, instrument makers, steam-fitters and the like are first taught the mathematical sciences as they relate to arithmetic and some algebra, mensuration and some geometry and an introduction into trigonometry. Abstract teaching is avoided as far as possible; by this I mean that we do not call merely on the boy's memory in asking him to tell us how much 4 x 3 x 6 is, but rather put the same problem to him in its application to industrial conditions, by asking him how much electrical energy,

expressed in certain units, is required to light a factory consisting of three work-rooms, in each of which there are four arc lamps each requiring six units of electricity for proper operation. When we state the problem in this way we briefly tell what an arc lamp is by showing such a lamp and explaining in a few words the principle of its operation; we also explain briefly the meaning of an ampere as an unit of measurement.

In the teaching of mensuration much emphasis is laid on the figuring out of surfaces and the weights of machine elements. The teaching of trigonometry proceeds along similar lines, but while all other apprentices are required to learn trigonometric functions and the solution of trigonometric problems, molder apprentices on account of the shortness of their apprentice period and because also their work would likely never require that knowledge of them, are excused from this particular study; some, however, take it at their own request.

Apprentices are taught, furthermore, elements of mechanics, the essentials of power transmission as it relates to pulleys, belts and chains, and gearing, the mechanics and strength of materials, the knowledge of which will give them a better understanding of the characteristics and uses of materials of construction and how to calculate the required strength of a machine part under given conditions of load. Then follows a brief outline of the prime movers as they utilize air, water, steam or other vapors, oils or electricity as their motive force. Again, molder apprentices take only that part of the program which falls within their allotted apprentice period; and unless it is done at their request they do not get instruction in magnetism and electricity, which in its elementary treatment is taught all other apprentices. In all these subjects, so far as possible and practical, problems relating to the industrial life of the apprentices are selected; with many of these problems the apprentices have come in contact in their work in the foundry and shops, and the solution of many more will be required of them later on when they have become skilled mechanics, foremen or superintendents.

Another important phase of the educational work relates to the teaching of mechanical and freehand drawing, and tool designing. The apprentices are first shown how to use drawing instruments in the making of straight and curved lines and combinations

of the same, and then are taught projection. This instruction is not for the purpose of making mechanical draftsmen of the apprentices, although some with ability for such work graduate into positions as draftsmen and designers. It is considered essential in the light of giving a foundation for a correct reading and better understanding of mechanical drawings, in accordance with which certain work is to be performed; and for the subsequent instruction in total designing. Before this latter work, however, is taken up, apprentices are given a brief course, all too brief, in freehand sketching in order that they may acquire the art and ability to express themselves quickly on paper in the language of the technical man, in lines and mechanical shapes. The art of good and quick freehand sketching so much needed by the mechanic, the foreman, the superintendent, the designer and the engineer, is all too frequently lacking, or only insufficiently developed in these men. What a valuable asset it would prove to our engineers and industrial managers if they had had an adequate course of instruction in this work as part of their mechanical drawing instruction at school!

Instruction in tool designing is not made a required part of the program for molder apprentices; pattern-maker apprentices are taught some of it while machinist, tool-maker and instrument-maker apprentices are given a rather extended course in this work. The work deals largely with the proper designing of jigs which are auxiliary apparatus by means of which certain operations may be performed quickly and with greatest accuracy on a large number of pieces of the same shape and character. If for instance exactly the same number and sizes of holes are to be drilled in one hundred or a thousand bearing caps, it would be suicidal from the manufacturing standpoint to lay out the location of these holes on each individual bearing cap and then drill the holes in accordance with engineering requirements. A jig must, therefore, be designed and constructed containing the required number and sizes of holes in hardened steel bushings inserted in the jig, which can be readily fastened over the individual bearing cap and through the bushings of which the workman can push through the drill of required size. It is obvious that it requires good mechanical conception and practical knowledge to design this jig so as to secure the saving of minutes even in

attaching the jig to the bearing cap and doing the necessary work on the drill press. If our draftsmen, designers and engineers had ability along lines of jig designing they would no doubt design machinery or parts of the same with better regard to its manufacture, especially where wholesale production comes into play.

In addition to the major subjects already outlined, we endeavor, through brief courses, to give the apprentices a better knowledge of correct spelling and concise written expression on given subjects, particularly in reference to technical terms, than they have received in their previous school training. We also add a brief period of instruction in industrial history through which we seek to make the apprentices acquainted with the lives of such men as Watt, Stephenson, Faraday and other inventors and scientists of the times gone by, and of similar men of today who by their thoughts and work have advanced the mechanical arts and sciences and, through them, the happiness of the people. In pointing out these lives and achievements, we are endeavoring to develop in the apprentices a better knowledge of the state of the art today, and to awaken in the apprentices an ambition and hope that by hard application to work they may be able to accomplish, if even only to a small degree, what these men have accomplished for the benefit and welfare of mankind.

Once or twice every week apprentices are given half an hour of what we term "Practical Talks." The superintendent of the apprentices or one of his assistants, or some other superintendent or foreman of the factory, on these occasions speaks to the apprentices of one of the problems or occurrences which he has met in his practical work and of which the apprentices should know in order that they might avoid the mistakes which others have made and the pitfalls into which others have fallen. During the half hour periods reserved for "Practical Talks" the works doctor can speak to the apprentices on personal hygiene, on accident prevention and the treatment of accidental injuries, while representatives of our business organization can instruct the apprentices in the rules and regulations of the factory and the proper performance of such clerical work, as filling out time cards, the making of records, etc., which more or less forms part of the work of most journeymen, foremen and superintendents.

Apprentices with a high school education who are being

trained for future draftsmen, designers, electrical testers, installation engineers and similar work receive class-room instruction based upon a complete high school program. Their mathematics starts with advanced algebra and comprises brief instruction in trigonometry and analytical geometry, with a mere introduction to calculus. In view of the preliminary training in mechanical drawing which they have already had in high schools, a smaller amount of time is devoted to mechanical drawing and freehand sketching and tool designing, in order that the greater part of the time may be reserved for instruction in mechanics, machine design, thermo-dynamics, elementary electricity, electrical measurements, and the theory and application of direct and alternating current machinery.

The next pictures (Figs. 15, 16, 17) show some of the classrooms and illustrate in particular the smallness of each class. During the beginning of the class-room instruction as many as eighteen and twenty apprentices may be allowed in one classroom. In the more advanced classes, however, the number is kept smaller and if possible below twelve in order that the instructor may be enabled to deal largely with each individual apprentice. As I have repeatedly told the instructors, it is of little importance how the apprentices are taught as long as the teaching is along such lines as to awaken in the boys the ability to think clearly, reason logically and properly apply to the practical problems of the day the theoretical knowledge acquired by them or to be found in readily available books. I also tell each instructor that he will the sooner succeed in his work if he will take the attitude, not of a teacher toward his pupil, but of a father toward his son, for he will then, like a father to his son, explain to his pupil again and again the same thing until the boy finally understands it. Just as little as a father would be willing to give his son merely a bad marking and let it go at that, so should the teacher consider the marking of the daily class-room work and examination papers merely as an incidental necessity of organization, and should endeavor with infinite patience and through the right attitude to make the boy sit up and take notice, understand and properly apply that which he is trying to teach him.

The diploma which the apprentice receives at the successful completion of the apprentice course, enumerates the subjects

in which he has obtained instruction and passed satisfactory examination. No mention is made of the subjects in which the apprentice has not been able to pass satisfactorily. The diploma, therefore, states what the apprentice knows in our judgment and not some of the things in which he is deficient. When an apprentice has completed all class-room studies, the diploma is marked at the bottom with the words "Completed Course." Our graduated apprentices are quite proud of their diplomas and we

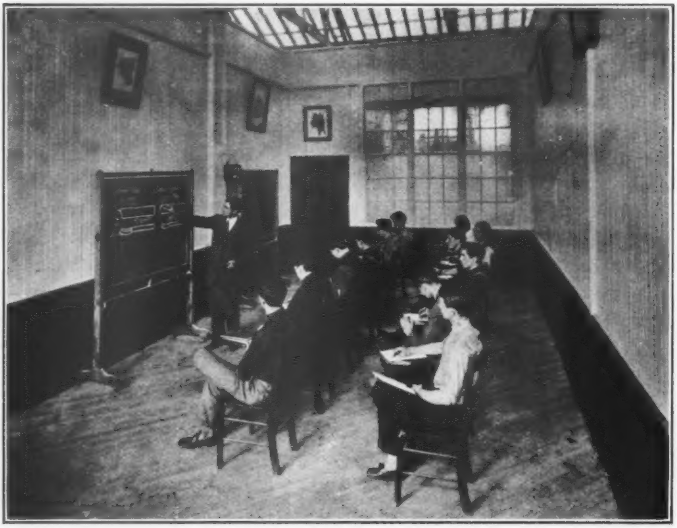

FIG. 15.—PRACTICAL TALK IN THE CLASS ROOM, APPRENTICE DEPARTMENT, GENERAL ELECTRIC COMPANY, LYNN WORKS.

understand that the possession of such a diploma has made it rather easy for our graduates to secure outside positions if they do not want to remain with our Company.

Through the next picture (Fig. 18), I wish to point out the fact that we are also paying some attention to the development of social life among the apprentices; one or two picnics during the summer and several dances during the winter are part of our program. Most of the apprentices belong to the Apprentice

Association and some of them are members of the apprentice orchestra. Graduated apprentices also belong to an association, and those living within reasonable distance of Lynn attend the annual alumni apprentice dinner.

Much more could be said on the subject of apprentice training, and much more would I like to say if time permitted. This hope, however, I wish to express before closing, that you all would realize the necessity and the importance of first thinking about this subject and then doing something worth while along the right

FIG. 16.—CLASS IN TOOL DESIGN, APPRENTICE DEPARTMENT, GENERAL ELECTRIC COMPANY, LYNN WORKS.

lines. If you will enthusiastically enter into work of this character you will readily overcome some of the obstacles that may now loom up in your minds, but which upon closer study will be found to exist largely in the imagination. It has been claimed that opposition to apprentice training exists in certain quarters, and yet I find no such opposition if the whole matter is presented in the proper light. If any of you has a son who has mechanical inclination and desires to prepare himself for a useful life as a

molder, a pattern-maker or a mechanic, you, as a father would want him to receive such instruction in a thorough and systematic manner, regardless of how many other fathers' sons are already receiving the same kind of instruction. You surely would not want your son to be hampered by any unreasonable restrictions which seek to prevent the full development of that which is within him; you would want to give to him that opportunity which he as a boy, and you for him as his father, have a right to ask of the

FIG. 17.—A CLASS IN MATHEMATICS, APPRENTICE DEPARTMENT, GENERAL ELECTRIC COMPANY, LYNN WORKS.

government of the United States, namely, a chance and an opportunity to prepare himself for a life of usefulness and a life of proper enjoyment. Now, if you put this same problem in the same light to any other father whose son seeks training along practical mechanical lines, you will find, as I always have found, that there is no reasonable objection on the part of any right-thinking man to the introduction of initial vocational training into the public schools, and of well-conducted, practical apprenticeship systems

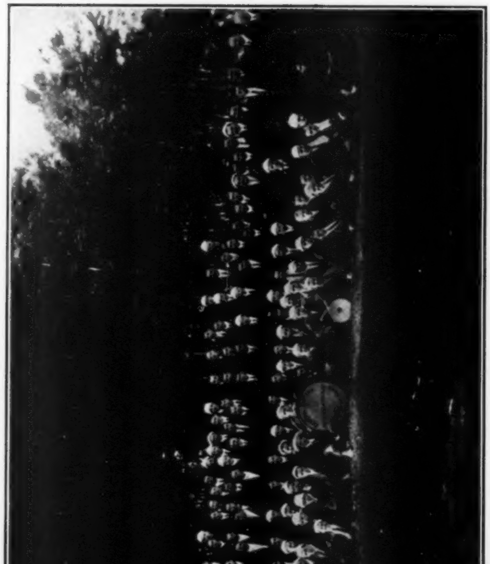

FIG. 18.

into any foundry or factory. The objector will only object in the final analysis to short-cut methods which may give the boy the idea that he knows something, without really giving him the foundation for knowledge and knowledge itself. Such objection is fully justified, for we cannot afford to build haphazardly when it comes to training of those who before long will have to step into our shoes and carry on the work of the world, more effectively, more efficiently and even more enthusiastically, I hope, than we ourselves are doing it today.

DISCUSSION.

The Chairman.—I think we have all enjoyed this very able address. Perhaps there are some of you who would like to ask some questions of Mr. Alexander, and I am sure he will be glad to answer them.

Mr. Crawford.—Mr. President, Mr. Alexander's statement in regard to the machine shop—I, for one, would like if he should have dwelt a little more on the foundry aspect of the matter, because, while I realize some of the difficulties that attach to the machine shop, I realize a great many more of the difficulties that attach to the foundry. I do not know of any other employer that is doing more for the education of his apprentices than the General Electric Company is doing, and I would like the foundry aspect gone into a little more. Mr. Alexander showed us the core room. He spoke of the formation of gases, the use of cores, the setting of cores, the necessity of accurate work in setting cores—are these subjects taught to the apprentices? Are they also taught the running of the cupola? These are some of the things that Mr. Alexander could enlighten us on and in which we would feel very much interested.

Mr. Alexander.—The same principles underlying the training of machinists apply, in my opinion, to the training of foundrymen. I see, however, as well as the gentleman does, added difficulties in the training of foundrymen, for most foundries are small as compared with most machine shops and there is not the opportunity, therefore, of setting up extended systems of training; yet even for comparatively small foundries a similar system can be introduced. Where from an economic standpoint this is not possible, several foundry owners in the same locality can join hands in a common effort, or foundry owners represented in this Association can join hands through the Association in accomplishing the same or similar results. Take, for instance, a city that has several foundries, none of them large enough independently to institute class-room work. These foundries could engage

jointly a superintendent of apprentices who could see to it that each foundry carries an adequate share of foundry apprentices, gives them the proper training along well-conceived practical lines and with due regard to the productive conditions of the foundry, and that all apprentices assemble at four o'clock in the afternoon, or whatever time you may set, in a common school room, in one of the foundries, in a Y. M. C. A. building or a public school building, for instruction. The instruction should, of course, take particular cognizance of foundry work. There should be practical talks dealing with foundry problems; through a course in "Chemistry of materials" apprentices should be made acquainted with the various sands and their properties, with binders and with all other materials of the foundry. I realize that you will find, as we have found, that there are comparatively few boys who are willing to go into the foundry to learn the molder's trade. The knowledge has not sufficiently gone abroad that a skilled foundryman is ——

Mr. Crawford.—A fellow beyond price.

Mr. Alexander.—Absolutely; there are relatively few skilled foundrymen in this country, and there is, therefore, a greater opportunity for boys who wish to learn a trade in this than in most other industrial fields. The work is dirty, to be sure, and it is that phase which is known to the boys the country over and which makes foundry work undesirable. We individually, and the Association as a whole, should therefore do something to educate the boys as well as their parents and the teachers, to the fact that a foundry is a splendid field for useful work, and that a skilled molder or a skilled melter is a man almost without price. With more boys seeking foundry training through apprenticeship we can, of course, more readily institute apprentice courses; in the meantime, however, we must patiently but persistently lay the foundation for this broader work by dealing with the situation now even though it will mean the training of only a handful of molder apprentices. [Applause.]

Mr. Kreuzpointner.—Your Committee on Industrial Education has made a thorough inquiry into the possibilities of serving the foundry industry through the schools. The teaching of foundry work in machine shops, as just explained, is always, I find, a mere side-show in our large factories. Even in the Pennsylvania

Railroad shops at Altoona they do not pay any particular attention to foundry work in their apprentice school. Much of the necessary knowledge in the foundry that the gentleman has just mentioned is more of a scientific nature and our schools can do in that respect more than the foundry attached to a machine shop, and I do believe, and believe I have pointed out several times that the foundrymen putting pressure to bear upon the schools to develop the foundry work as much as they have developed the machinery work in their schools, will help the foundries more through the schools in this particular instance of foundry teaching than the foundry attached to the machine shop ever can do. Up at Winnipeg they just built two technical schools, each one costing $850,000 including the equipment, and they have no foundry. They promised to have one as soon as possible, and I have advised them to do just the thing in that school that Mr. Alexander has mentioned, to give them that insight into foundry work which they very seldom get in the foundry attached to a machine shop, and I, as Chairman of your Educational Committee, would suggest that, as pointed out before, that foundrymen get together in their various communities and bring pressure to bear upon the school people to get help in this respect.

Mr. Hillix (of Stout Institute, Menomonie, Wis.).—I would like to ask Mr. Alexander how they get their teachers for these apprentices. If they have any special training for their foremen or their teachers, to teach them to organize their work so that they can give it to the boys without waste of time? I have found in my experience that the average foreman lacks several things of making a good teacher; that is, he should have certain training to learn to organize his work so that he will teach the essentials and not spend time on non-essentials.

Mr. Alexander.—I feel almost inclined to answer that question in Yankee fashion by asking another question—how can you keep the instructors after you have trained them? There are so many trade and manual training schools and colleges which have recently taken hold of the idea of industrial education and are now pulling away from the manufacturers those teachers whom they have developed. Yet, after all, looking at the matter in a broad light, we should not entirely begrudge this situation, for by distributing some of our own instructors among the various

schools we surely help to get a more practical viewpoint into the schools. The problem of securing good instructors for apprenticeship training is just the same as the problem of securing good men for any other work.

The trade instructors must be men of skill, ingenuity and imagination; the class-room instructors must have theoretical knowledge and imagination; and both must also have that something that allows them to convey their own ideas to the young and only partially developed mind in such a way as to enlighten and stimulate that mind. You will find right among your own skilled employees men who can be developed into efficient trade instructors. You may also find on your office staff men who have the requisite knowledge and ability to teach in the class-rooms. It is not essential that the class-room teachers be college trained men, except those who are called upon to teach the higher branches of mathematics, and mechanics and advanced electricity. If the class-room instructor possesses practical experience besides theoretical knowledge, he will of course prove a better instructor, and will more readily inspire the apprentices with confidence. In any event, the trade instructor as well as the class-room instructor must have the right viewpoint, the viewpoint of the father toward his son, as I pointed out before. If he does not possess the right viewpoint he will never make an efficient instructor, and no amount of study of pedagogy will overcome this vital deficiency. [Applause.]

In the Lynn training rooms we developed many instructors for our own purposes and to replace those whom we sent to other factories of the General Electric Company where apprenticeship systems were started, and those who left us to take positions in other factories and schools. We have also assisted other manufacturers by allowing those whom they selected for their apprentice instructors to spend a month or two in our training rooms as assistant instructors, although not paid by us. If our Company would permit it, I should be glad to render in this way some service to other employers. [Applause.]

Mr. Kreuzpointner.—It is one of the most difficult things to get teachers for these schools, and the Foundrymen's Association can help a great deal by bringing pressure to bear on the school people to send their teachers who are at present engaged in indus-

trial schools and will be so engaged, practical men from the shops, to send them to the summer school. It may be a satisfaction to the foundrymen to know that your chairman of the Educational Committee has served two weeks this last summer, one week at the Pennsylvania State College and one week at the Teachers' College of Columbia University for teaching teachers. I was invited to preside at the Round Table of Industrial Teachers at the Pennsylvania State College, and found the absolute necessity of teaching them good mechanics but giving them some larger insight into the mechanical work they get, which they can get at the summer schools, and at the same time get some knowledge of how to teach and an understanding of the educational organization of our country which they need. We can get plenty of good teachers by taking practical men and educating them up for a couple of years in the summer schools, but the school boards will not do it, they will not send the men there, they will not insist on their going there because they are paid so poorly, and as long as the teachers are paid so poorly, they will not make the sacrifice to go to these summer schools, and therefore you and all who are necessarily engaged in employing labor, as citizens, all of our industries should bring pressure to bear on the school authorities to pay these people to go to the summer schools and then we will get good teachers. The Director of Public Education of the city of Winnipeg insists that they be all practical men in those schools. He gives them a technical course on teaching and the technical basis of their work, and it works excellently, and if we all work together, if everyone of us, as a citizen, insists that the school authorities pay these people to go to the summer school, then we will get a good corps of teachers in a very short time.

AMERICAN CORE ROOM PRACTICE.

By H. M. Lane, Detroit, Mich.

From the Paper presented before the Foundrymen's Association of France, May, 1913.

The present foundry and core room practice of the United States is the outcome of certain economic conditions existing in this country. The rapid development of the country and the relative shortage of labor has resulted in a high labor cost or wage paid to the individual worker. If a product is to be manufactured at a given cost for the finished article and high wages must be paid it is self-evident that something must be done to increase the output of the individual.

Fortunately many of the American industries are such that specialization is possible in this country; for instance, the agricultural interests require the use of extensive machinery for harvesting the crops. In other lines of manufacture, machinery has to be used to an extent never heard of before. Special examples of this are found in the textile and the boot and shoe industries. One of the finest foundries in the United States is maintained by The United Shoe Machinery Company at Beverly, Mass. In like manner there are a half dozen very large textile machinery manufacturers catering to the cotton-machine trade.

Other lines have developed in a similar way, and this has made possible the specialization of the design of machinery which in turn has made possible large orders of duplicate work in the foundry. Orders of from 100,000 to 1,000,000 castings from one pattern are not uncommon in the United States.

For making a larger output of castings a big variety of molding machines have been developed, and the American molding machine, unlike the French, is intended in most cases to perform a limited number of operations with a very great speed in place of performing several operations with extreme accuracy. It is

true that in much of the American molding machine work great accuracy is also accomplished, but even then considerable of the work is done by hand.

American foundries, however, have gone into the use of handling machinery much more extensively than those abroad, and all of this work has influenced the core room.

Until recently the cores were mostly made in boxes by hand, the increase in output being obtained by using metal driers for supporting the cores, by using very high grade boxes, and by using special core mixtures which were suitable for rapid work in all departments. The oil sand core has been developed in America to an extent that is probably unknown in any other country, and there are hundreds of foundries in the United States using upwards of $100 worth of oil per week, and there are some that use over $100 a day.

Up to a few years ago all of the work in this field was the result of individual experimentation on the part of manufacturers. Most if not all of the core binders in use originated from experiments carried on in foundries. The core ovens, or as they are called in England, core stoves, used in this country have for the most part been rather crude affairs in that up to recently they were of the natural draft type.

Comparatively little has been done in most foundries to control the temperatures in core ovens, and few foundries have installed pyrometers or thermometers on their core ovens. Some fifteen years ago when getting up the Shop and Foundry Practice course for the International Correspondence Schools the writer commenced an investigation into the underlying principles of coreroom practice. Later, with the collaberation of Mr. George H. Wadsworth, the inventor of a number of core machines, this work was continued principally at the plant of the Falls Rivet and Machine Company at Cuyahoga Falls, Ohio.

Considerable success was obtained early in the work, but in the attempt to transfer the work to other plants unexpected failures were encountered. This indicated plainly that there was lacking a knowledge of the underlying principles and particularly of the reactions which took place between the different binders and between the sand and the binder.

In this country we distinguish between the green binder and

the dry binder. By a given binder we mean the binder which holds the green sand in place before it is baked. Unfortunately there is considerable confusion in foundry nomenclature in that the term green sand is used in a number of different ways. For instance all molds which are made from a molding sand carrying some clay which is formed without subsequent drying are called green sand molds. In like manner cores made from a similar molding sand mix are called green sand cores. Such cores are frequently used where the castings are relatively thin, as for instance in the soil pipe trade.

In the aluminum casting industry, in this country the expression of "green halving a core" means that the lower half of the core is made from the ordinary core mixture and baked, and the upper half is then to be formed from ordinary molding sand such as is used for a green sand mold, and placed in the mold without baking. In most other industries the expression to "green half a core" means that one half of it is made and baked, and then the other half is formed on top of this of an ordinary core mixture, the whole returned to the core oven and baked again, and thus forming a complete dry sand core without the use of a drier, or without the use of the bedding sand supporting the core while it is drying.

Binders in Common Use.

To reduce the expense of cores many attempts have been made to find cheap binders. The binders now in general use may be divided into the following classes: Oil binders made from the drying oils used in the paint trade, such as linseed oil, cottonseed oil, corn oil, soyabean oil, fish oil, whale oil, etc. Oils made from a combination of drying oils and gums dissolved in mineral oils, these gums generally being rosin in some form. Oils made wholly from gums dissolved in mineral oil. Such oils are generally more sticky than the others and give more or less trouble in the core boxes, but they are very cheap, and hence have found favor with many.

Binders having a pitch or gum base; these include rosin which is ground and mixed with the sand; also pitch derived from the purification of coaltar, or other products. The trouble with these last mentioned pitches is that the coke which forms

when the metal is poured around the core is so hard that it renders the cleaning out of the core difficult. To overcome this the black core compounds used in the United States are mostly composed of pitch mixed with what is called sea-coal. This is a ground bituminous coal made from a regular gas coal high in volatile products. Coke dust is also sometimes used and in the better grades of binders, "dextrin." Dextrin has the advantage that it also acts as a green binder, that is, one which will hold the core in place before it is baked.

This class of dry compounds including both the black compounds and rosin, bind the sand by the melting of the rosin or pitch, and its flowing between the sand particles.

There is another extensive series of binders which includes the paste class. These are flour, either made from wheat or rye; starch usually made from corn and dextrin. To this class of binders there is one objection, and that is the cores made from them if exposed to dampness for some time will gather moisture and become soft. Hence, these cores must be kept in a dry place until just before they are used, and must not be left in green sand molds for a considerable time before they are poured.

There are a few foundries in this country which for their large cores use a considerable portion of clay with flour, thus getting better moisture-resisting properties.

There is another broad class of binders which can be called the water-soluble binders. These include sour beer and "returns" from the rum distillery; molasses, either from cane or beet sugar works, and the refined extract from the sulphite paper industry which is marketed in this country in a neutral condition under the name of "glutrin." All of these binders possess some special advantages, but the first two mentioned are only used where there is a local supply, and are not as efficient as the last two mentioned. The principal objection to molasses is that samples from various sources differ in strength, and that it is also subject to fermentation which greatly reduces its strength. For this reason for the general class of work the sulphite liquor product has been found the cheapest of the water-soluble binders.

MEMORANDUM ON CUPOLA LININGS.

By W. A. Griswold, Nashville, Tenn.

The following record of a cupola lining will be of interest to foundrymen, as an instance of the length of life attainable when the bricks are given proper treatment.

It is well known that even with the best qualities of fire-bricks for cupola linings, that is the highest refractory qualities combined with a fine grained structure to resist abrasion as well as chemical action through contact with the ash of the fuel, poor results are obtained when the bricks are laid with inferior clays for a mortar. The more readily fusible clays thus introduced between the best of bricks will start a slagging action within the range of the melting zone, and the result is a more or less rapid washing away of the lining. If, coupled to this, the daubing is also prepared with clays high in fluxing ingredients such as lime, oxide of iron, alkalies, etc.—and how many of our smaller foundries make use of local clay banks for this work—the result will be a necessary relining of the melting zone at very frequent intervals.

In the case presented herewith, the fire-bricks were laid without any clay mortar whatever. They were placed to within $\frac{3}{4}$ in. of the shell, and the space thus left filled with parting sand. Care was taken to have the joints as small as could be made. Charging the cupola was carried on with the ordinary care that should be given this work. The blast pressure ran from 12 to 15 ounces, the melting rate was from $14\frac{1}{2}$ to 16 tons per hour, the cupola diameter inside the lining 66 in., and the melting ratio from 8.1 to 8.4 lb. iron per pound of coke. From the above figures it will be seen that full returns were expected from the cupola, and the lining was not "nursed" by any means.

The lining was put in June 2, 1912, and no new bricks were put in until the cupola was again relined October 19, 1913, it being deemed inadvisable to take any chances. After the lining was out, however, it was seen that the cupola could have been run for another one hundred heats safely.

As the castings to be made are all of the lightest character, consisting entirely of stove plate and hollow-ware, very hot iron is required. This condition is accentuated by the fact that after tapping into bull-ladles holding about a ton each, the metal is carried to the different sections of the molding room, poured into hand ladles, and then into the molds. While the foreman gives some attention to the cupola daily, yet all the work about it is done by a set of green negroes.

The Melting Record of the lining is as follows:

1912.	No. of Days.	Lbs. of Iron melted per Month.
June	24	1,387,500
July	26	1,437,000
August	27	1,569,000
September	25	1,555,500
October	27	1,665,500
November	26	1,494,000
December	25	1,402,000
1913.		
January	27	1,555,500
February	24	1,410,000
March	26	1,580,000
April	26	1,605,000
May	27	1,579,000
June	25	1,493,000
July	26	1,572,000
August	26	1,618,000
September	26	1,630,000
October	16	998,500
Total	429	25,551,500

Total Melt, 12,775.75 tons.

Average Melt per day, 29.8 tons.

From the above it will be seen that where foundrymen have to reline the melting zone frequently, not to speak of the rest of the cupola lining, a little attention to the work in the first place, the exclusion of materials allowing fluxing action between the bricks themselves, careful chipping to remove slag that will continue to eat in further with every melt, and at the same time allow any daubing put on to slip off the moment the slag behind becomes soft—will result in maintaining the integrity of the lining for a surprising tonnage and length of time.

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